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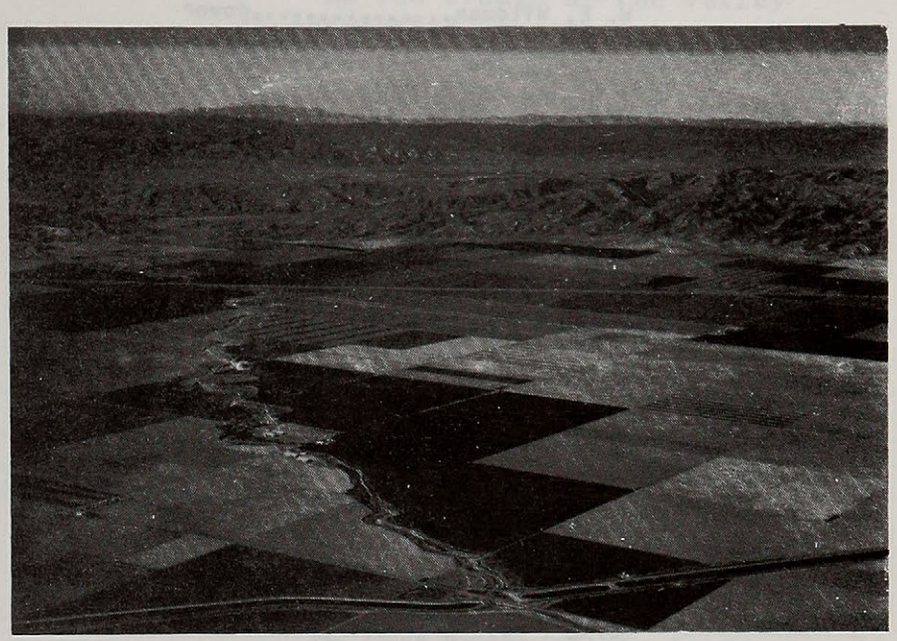
San Joaquin Valley Soils and Their Geologic Origin

W. E. Wildman

Most soils are derived from solid rock materials. In the soil the rock minerals are (1) present in very small particles, (2) loosely assembled, and (3) have pore spaces between them The balance between soil particles and pore spaces allows water and air to circulate and provides a medium in which plant roots can proliferate to make intimate contact with soil particles to obtain their requirements of water, air, and mineral nutrients.

Rock materials become soils through a process called weathering. Rocks are attacked both by physical forces and chemical reactions. Physical forces are those which break the rock down into finer particles and move those particles from one place to another. They include freezing and thawing, and abrasion and transport by water, ice, and wind. Chemical reactions include decomposition and solution of some of the rock-forming elements by water made weakly acidic with carbon dioxide, oxidation of iron and aluminum by atmospheric oxygen, and resynthesis of new more stable clay minerals from these breakdown products. These reactions are very slow, but even on top of Half Dome, there is a thin layer of soil with a few plants growing.



This aerial view shows Panoche Creek crossing part of the Panoche fan west of Mendota. The California Aqueduct is in the foreground, Interstate 5 in the middle ground, and Panoche Valley beyond the first range of hills.

The factors most important in the formation of San Joaquin Valley soils are parent material, land position, and age. Since essentially all of the central valley soils are alluvial, that is, deposited by streams flowing comprising the Sierra Nevada and Coast Ranges provide the parent material for the soils. The geologic map shows that the Sierra Nevada are largely granitic rocks, but with a strip of metamorphosed sedimentary and volcanic rocks bordering the east side of the northern part of the San Joaquin Valley. These metamorphic rocks are the parent material for a few alluvial fans from streams that arise at lower elevations, but most east side rivers cut deeply into the granitic rocks and result in fans that

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Photo Credit:

William Wildman

reflect the coarse texture of these rocks. The Coast Ranges, on the other hand, are largely unmetamorphosed sedimentary rocks that produce finer textured alluvium from sandstone and shale.

It is informative to follow a transect of soils across the San Joaquin Valley. Storie's Generalized Soil Map of California shows the valley soil differences in relation to landscape position and age. The first alluvial soils on the east side are very old. They are now on terraces above the level of the most alluvial fans. This is due to lowering of the valley trough and incising of the streams that once made these old fans.

In the Merced area (Figure 1a), the ancient soils of the Redding Series are made from cobbly alluvium from mixed rock sources. These soils are believed to be greater than half a million years old. They are very acid and infertile, and have a strongly cemented hardpan within one to two feet of the soil surface. These soils are used only for rangeland. Further down the slope, but still on terraces, are the San Joaquin soils, considerably younger than the Redding, but perhaps as old as 250,000 years. These soils were formed from granitic alluvium and also have a cemented hardpan. In contrast to the Redding soils, the San Joaquin soils are reasonably fertile and productive when deep ripped to shatter the hardpan.

Continuing westward, the young and recent alluvial soils are in the most favored landscape position for deep-rooted crops that need good drainage. These are the Hanford and similar soils on which the most productive vineyards and orchards grow. These soils range from 500 years or less up to perhaps 20,000 years in age.

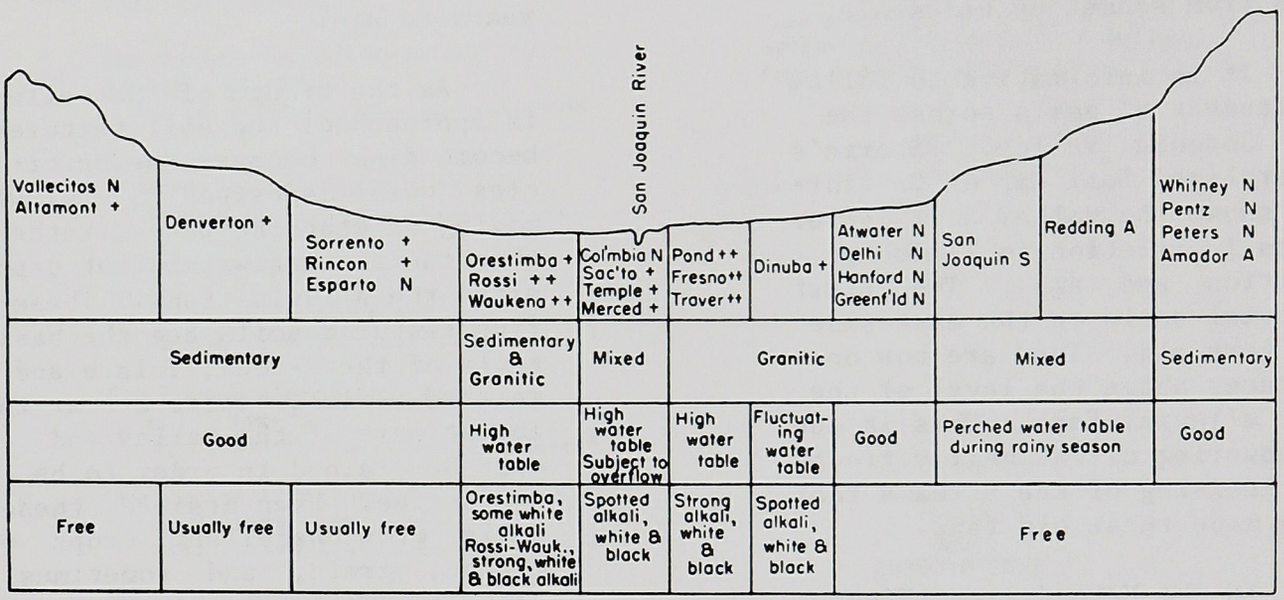
As the trough of the valley is approached, the soil textures become finer because the particles were deposited by slowly moving or standing water, rather than the flowing water that deposited the alluvial fans. These fine textured soils are the basin soils of the Merced, Tulare and related series. These are at the lowest part of the valley and must be drained in order to be productive. When drained, these soils grow excellent crops of cotton, grain, and sometimes alfalfa. Their fine texture and reduced aeration do not favor orchard or vineyard plantings.

On both sides of the basin soils is a strip of soils high high in soluble salts on a landscape position called the basin rim. By virtue of their slightly higher position, these soils accumulated salts by evaporation of water that had moved laterally through the soil from the basin. Many of these soils have been reclaimed but some areas have been difficult or uneconomical to reclaim because of very high levels of sodium, subsoil layers that inhibit leaching, or lack of adequate drainage.

West of the basin and basin rim soils are the young alluvial soils from the sedimentary rocks of the Coast Ranges. The Panoche soils are a widespread series that formed from alluvium from sandstones and shales. They occur not only on the Panoche

Fig. 1a. Cross section of San Joaquin Valley soils near Merced.

Annual rainfall at Merced 11.81"
" " "Newman 10.06"

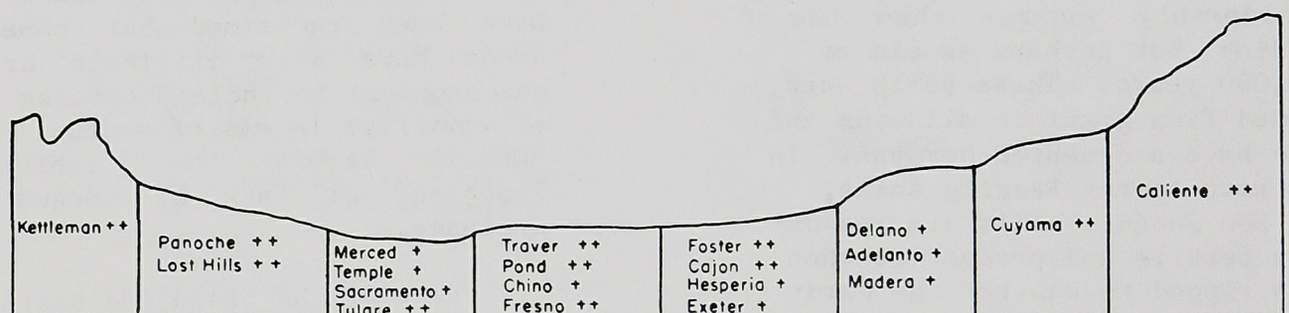


	Vallecitos N Altamont +	Denverton +	Sorrento + Rincon + Esparto N	Orestimba + Rossi + + Waukena + +	Col'mbia N Sac'to + Temple + Merced +	Pond + + Fresno + + Traver + +	Dinuba +	Atwater N Delhi N Hanford N Greenf'ld N	San Joaquin S	Redding A	Whitney N Pentz N Peters N Amador A
PARENT MATERIAL	Sedimentary			Sedimentary & Granitic	Mixed	Granitic			Mixed		Sedimentary
DRAINAGE CONDITIONS	Good			High water table	High water table Subject to overflow	High water table	Fluctuating water table	Good	Perched water table during rainy season		Good
ALKALI	Free	Usually free	Usually free	Orestimba, some white alkali Rossi-Wauk., strong, white & black alkali	Spotted alkali, white & black	Strong alkali, white & black	Spotted alkali, white & black	Free			

++ = Calcareous throughout
+ = Calcareous subsoils
N = Neutral
S = Slightly acid
A = Moderately to strongly acid

Fig. 1b. Cross section of San Joaquin Valley soils near Bakersfield.

Annual rainfall at Bakersfield 6.12"
" " " Maricopa 5.69"



	Kettleman + +	Panoche + + Lost Hills + +	Merced + Temple + Sacramento + Tulare + +	Traver + + Pond + + Chino + Fresno + +	Foster + + Cajon + + Hesperia + Exeter +	Delano + Adelanto + Madera +	Cuyama + +	Caliente + +
PARENT MATERIAL	Sedimentary		Mixed	Granitic			Mixed	Sedimentary
DRAINAGE CONDITIONS	Good	Good	High water table Subject to overflow	High water table	Foster soils have flucuating water table Others good	Good		
ALKALI	Occasionally some white alkali	Panoche - Occasionally some white alkali Lost Hills - Usually some white alkali	Spotted alkali, both white and black	Pond - Strong, white and black alkali Chino - Spotted alkali - white and black	Foster and Cajon - Spotted alkali - white and black Others usually free	Free	Occasionally some white and black alkali	Free

++ = Calcareous throughout
+ = Calcareous subsoil

Creek fan (cover photo) but along the west side as far south as the fans west of Bakersfield (Figure 1b). Because of lower precipitation on the west side, these fans are steeper and shorter than the east side fans. But they are also finer textured because of the finer textured rocks from which they are derived. These soils are highly productive for cotton and other field crops, with orchards and vineyards in some areas. The west side does not have ancient terraces corresponding to those on the east side. There are modest increases in clay in some of the older soil profiles, but no cemented hardpans.

Landsat images can be used to illustrate the increase in irrigated agriculture on the west side of the San Joaquin Valley between 1972 and 1983. In western Kern and Kings Counties there has been a considerable increase. Further north in Fresno County, all the land between Interstate 5 and the foothills to the west is now irrigated. This is on the upper edge of the Panoche and Little Panoche Creek fans, which have been suggested by some as the source of the selenium that is accumulating in drainage waters in the Kesterson Reservoir. Whether this is the case or not, it should be realized that the widely mapped Panoche soils have come from various formations in the Coast Ranges. While these soils are morphologically similar to those on the Panoche fan, they may be dissimilar in regard to trace elements such as selenium.

Selenium in the Soils of the West Side of the San Joaquin Valley

Rodney J. Arkley

Selenium is present in soil drainage waters at levels toxic to the aquatic fauna. Water analysis by the USBR shows that 20 samples contained from 0.01 to 0.10 ppm of selenium; 43 samples contained from 0.002 to 0.010 ppm. The concentration and distribution of soil selenium is poorly known except that the USBR water samples indicate that the alluvial fans of Panoche and Little Panoche Creek have soils with considerable selenium. Soil analyses of the area have concentrated on elements toxic to plants, such as boron, so little is known about selenium.

The source of seleneium in the soils and drainage waters on alluvial fans such as that of Panoche Creek is the rock formations of the Coast Ranges. The alluvial fans of the area are fairly steep, sloping from the hills of the Coast Ranges eastward down to the nearly flat floor of the valley. The fans consist of superimposed wedges of alluvium soil of textures varying from very fine sandy loams to silt loams and clay loams. The wedges are thick toward the west and thin or disappear entirely toward the east. The alluvium is alkaline containing calcium carbonate (lime) and gypsum (calcium sulfate) and low, non-toxic levels of other soluble salts. Rainfall is low so that prior to irrigation the soils are not leached of these constituents. With irrigation, however, the soluble constituents including any seleneium are leached downward and laterally down the fans due to their stratified nature.

The percolating water accumulates at the edge of the valley floor and, as it evaporates from the soil surface, leaves the salts behind, thus creating extensive areas of saline soils. This process was active before irrigation to some extent, but is greatly accelerated by irrigation. It is the drainage from these salinized areas that contributes most of the soluble salts and selenium to the major drain systems of the San Joaquin Valley. In alkaline soils such as these, seleneium is always in the form of selenate, which is considerably more soluble than gypsum, though not nearly as soluble as sodium chloride or sulfate. Thus selenate moves readily with percolating water into the drains.

Geologic Sources of Selenium

Geologic formations of the Coast Ranges differ north and south of Coalinga. Southward the formations contain a great deal of boron salts so that the alluvial fans of western Kern County have soils that contain levels of boron toxic to crop plants; their content of selenium is unknown.

North of Coalinga, rock formations of the Coast Ranges include extensive areas of upper Cretaceous rocks, which are known to be sources of toxic levels of selenium in several western states. Fortunately, a general survey of selenium in the Cretaceous rocks of California was carried out by the USDA and reported in Technical Bulletin 783. These rocks were deposited about 150 million years ago in the very shallow seas, and the material was subsequently uplifted to form the Coast Ranges. The rocks are generally shales that contain lime and gypsum, and may contain selenium as well. Samples were analyzed from a number of counties containing Cretaceous rocks but the only high concentrations of selenium were found in the Moreno Formation representing the uppermost Cretaceous and often overlain by Eocene rocks. In western San Joaquin County along Hospital Creek, selenium concentrations were extremely high, up to 28 ppm. The sampling that was done was very widely scattered so that the extent of selenium-bearing rocks of this type is not known. However, the geologic map of California shows extensive outcropping of upper Cretaceous rocks as far south as Coalinga; there is little south of there. Extensive areas of this formation are exposed in the headwaters of both Panoche and Little Panoche Creeks.

The process by which selenium and other salts are deposited in the alluvial fans is as follows: the storms affecting the Coast Ranges west of the San Joaquin Valley produce small flows or floods that spread out on the fans and soak rapidly into the soil, which generally dry so that little water actually runs off to the valley floor. The moisture in the soil dries up during the long, hot summers leaving the soluble salts behind in the soil. Only the major streams carry much water clear to the valley floor and then only during the rare major storms.

Implications

Clearly all the alluvial fans on the west side of the San Joaquin Valley may contain selenium. To determine the severity and extent of the problem, the concentration of

selenium in the entire drainage system as farm south as Coalinga and perhaps farther south should be monitored on a year-round basis for several years. If all drainage water, both surface runoff and subsurface drains, were monitored, the fans containing selenium could be identified and an estimate of the amount of selenium expected to enter a major drain system could be obtained. This approach should be more effective than attempting to sample and analyze the soils because of the very large area involved and the fact that the concentration of selenium in the soils is very low except in the more saline areas.

If it is determined that a master drain would carry significant quantities of selenium, then a management plan should be devised that permits the flow into the Delta region to be stopped during the season when concentration of selenium is high, and the flow permitted during flood periods if it can be established that the selenium can be diluted to safe levels.

Distinctly, selenium from the discharge of a master drain from the San Joaquin Valley is a possible hazard to the fauna of the Delta and San Francisco Bay. The severity of the hazard is now unknown, but it must be considered before plans for construction and management of the drain are accepted.

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Salinity, Selenium... What are we to do?

E. F. Bullock and
R. D. Meyer

High salinity drainage water is generally considered one of irrigated agriculture's worst pollutants in California. Recent events also point to a specific problem--selenium at Kesterson Reservoir.

Kesterson Reservoir, located in Merced county east of Gustine in California's San Joaquin Valley, was built in 1971 by the U. S. Bureau of Reclamation (USBR) as part of the San Luis Drain Project. It was designed to regulate drainage flows in the drain prior to their discharge into the Sacramento-San Joaquin Delta. However, the drain north of Kesterson was not built. Consequently the Kesterson reservoir, which consists of twelve evaporation and storage ponds, serves as the half-completed drain's terminus.

Since 1972, Kesterson Reservoir has been managed as a wildlife refuge by the U. S. Fish and Wildlife Service (FWS). Before 1978 nonsaline surface runoff was the primary source of water discharged into the reservoir. Since 1981, saline drainage water has been the primary source. In 1983, 7000 acre-feet of water was collected from about 8000 acres of farmland on the west side of the San Joaquin Valley. Most of this farmland is located on the alluvial fan of the Panoche River, a highly productive agricultural area which has been farmed for 30 to 40 years.

In 1982, the FWS first noticed all was not well at Kes-

terson. Prior to the delivery of subsurface drain water, the reservoir supported many types of fish--largemouth and striped bass, catfish, carp, and mosquito fish. Since then, only mosquito fish have been found and they contain exceptionally high levels of selenium.

Since 1981, the selenium concentration of the drainage entering Kesterson has been about 400 mg/L (400 ppm): one extraordinary sample contained 1400 mg/L. In freshwater pond studies, 10 mg/L has been associated with fish population decline. After additional tests last September, FWS noted: "Full-strength drain water was toxic (lethal) to test fish in two days and to invertebrates in one day." Whether selenium, adverse pH or high salinity was responsible is not clear at this time.

Up the Food Chain

Fish and invertebrates are not the only victims of high selenium. Selenium biologically concentrates in the lower portion of the food chain which, in turn, is a source of food for higher order birds and mammals. Based on field observations at Kesterson in 1983, the incidence of waterfowl reproductive failure was abnormally high. Of 347 nests observed, 20 percent had visibly deformed chicks or embryos. Forty percent of coots' nests contained at least one visibly abnormal young. Coot eggs, when analyzed, had about 10 times the concentration of selenium normally found in waterfowl eggs. Although no mortalities were observed, selenium in the adult birds at Kesterson was also high: breast muscles were found to contain seven times more selenium than those of birds living nearby in a wildlife refuge unaffected by drainwater. Consequently, state and federal officials became concerned that people who ate the birds would be adversely affected by selenium and the areas was posted.

Extent of the Problem

As more west side valley land is drained, will the problem become worse? Unfortunately, we don't know.

Perhaps the high selenium drainage water is limited to localized areas within the Panoche and nearby alluvial fans. This is unlikely based on the distribution of high selenium shale deposits in the Coast Range as described in the previous article by Arkley and illustrated in Figure 1.

What Now?

Most observers agree the problem creates ramifications for San Joaquin Valley agriculture far beyond Kesterson itself. Should the San Luis Drain be completed as currently proposed, USBR plans to release drainwater at Chipps Island in the Sacramento-San Joaquin Delta. When originally proposed, the San Luis Drain was intended to serve about 100,000 acres of valley land. Today it is draining 8,000 acres. If completed as currently planned, the drain would service up to 500,000 west side valley acres releasing nearly 40,000 acre-feet of runoff yearly, most of it subsurface drainage. If the selenium levels in Delta waters are 2 mg/L and if the drainage water can be delivered with the aid of a diffuser, at 40 to 50 mg/L, then dilution beyond the diffuser should result in final selenium levels which are

less than 10 mg/L. These assumptions will undergo close examination because of the public concerns for the environmental quality of the Delta and San Francisco Bay.

Several alternative approaches for solving the drainage problem have been suggested. Some of the suggestions, and our own thoughts about them, are discussed below.

* Complete the San Luis Drain, but regionally collect high selenium drainage and detoxify it through "special treatment" prior to release into the drain.

One suggestion for detoxification is desalinization, but current desalting technologies carry severe handicaps which have made them unpopular in the past. First, they are expensive to operate, being both energy and land consumptive. Additionally, they produce brine which, under current law, must be handled and disposed of as a toxic hazardous waste.

Another suggestion has been to use algae laden ponds to absorb selenium into plant material. Unfortunately, here again large acreage would likely be required and the algal residues themselves would become a toxic hazardous material in need of proper disposal. In addition, nobody has actually tried this approach to see if it will work on the scale rquired.

* Discharge the high selenium waters directly to the ocean.

This alternative was originally proposed in the initial design of the San Luis Drain. This alternative has been unpopular primarily because of excessive construction and maintenance costs. A modification of this original proposal is to design the aquaduct to handle only excessively contaminated (and perhaps evapoconcentrated) drainage waters. The remainder of the area's drainage could be discharged to the Delta via the San Joaquin River or a completed San Luis Drain.

Such a plan is feasible if the volume of selenium contaminated water is low. But there are other factors to consider. An ocean side disposal should bypass the ecologically rich contenential shelf areas and release drain water into less biologically productive, deep-ocean areas. Two such deepwater areas exist near the coast, Monterey Bay and the mouth of San Francisco Bay. Already there are legislative hurdles in place against a Monterey Bay disposal. Clearly, extensive study and public debate will be required to determine the viability of this new approach.

* Water Conservation (improved irrigation management)

Many environmentalists put too much faith in this answer, and agriculturist not enough. The achievable efficiency with today's better irrigation practices on individual farms is about 80 to 85 percent. Higher efficiencies are extremely difficult to obtain because of the need to leach salts from the crop root zone, the nonuniformity of water application inherent in irrigation system design, and individual field variation.

Since drainage water is often reused for irrigation downslope, typical area-wide irrigation efficiencies are generally higher than measured on-farm efficiencies. USBR reports area wide irrigation efficiencies of about 80 percent on the west side valley (there is much debate among parties regarding the true value of this number). Water conservation efforts would likely increase efficiency and could decrease the amount of drainage effluent valley wide, but by how much? Studies have shown nearly as many farmers underirrigate as overirrigate. There may be much room for irrigation improvement in the Valley. However, unless saline drainage water can be safely stored for decades in on-farm or district evaporation ponds, a need for a valley wide farm drainage network remains.

* Prevent drainage of agricultural land underlain with high selenium water.

Under this proposal, probably some agricultural lands requiring drainage would go out of production, and others would be converted to less profitable crops. One often overlooked consequence may be districts or individual farms will build their own evaporation ponds which, as discussed later, could become a problem in itself.

Agriculturists see this as a very undesirable alternative, since individual farmers will be severely damaged financially. On the other hand, some environmentalists prefer this alternative, arguing there is already surplus of good agricultural farmland in the United States--farmland which does not require billion dollar taxpayer subsidies to keep productive.

* Dispose of (high selenium) drainage in individual on-farm ponds.

Without action on a valley drain or regional evaporation ponds, it is probable many individual farmers and drainage districts will construct their own evaporation ponds. Such action would again require large dedicated pond areas, and it would create potential environmental hazards such as groundwater contamination and waterfowl toxicity on each farm. One regulatory-minded observer called this option a potential "logistics nightmare" compared to fewer, public disposal facilities.

* Solar Pond--Reverse Osmosis Plant.

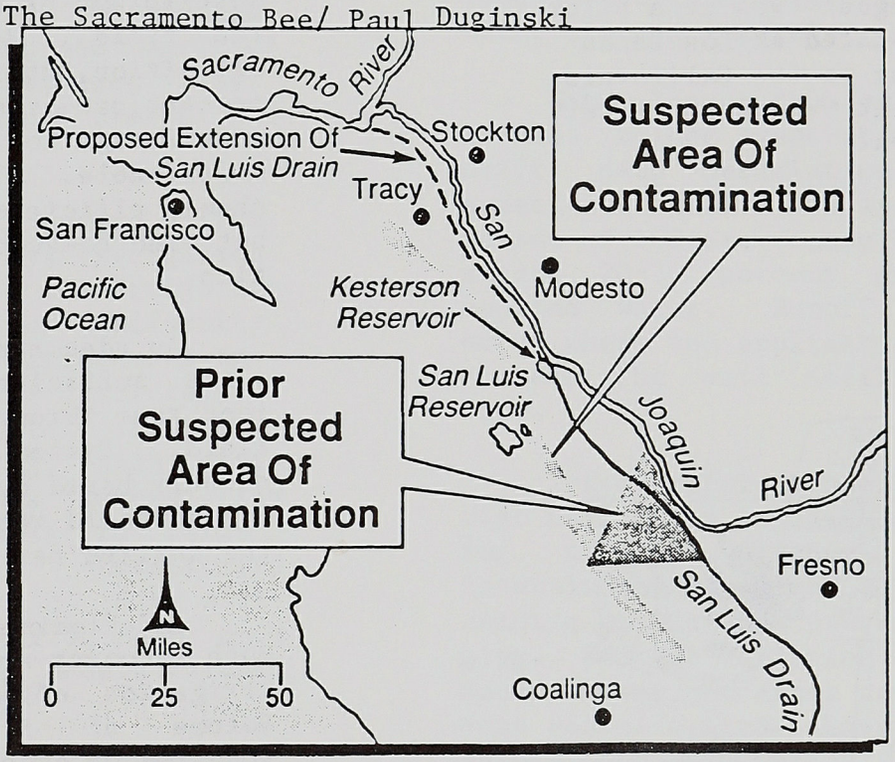
Such a facility generates desalted water and electricity. This technology will be tested as early as August 1984, at Los Banos. The solar pond contains a highly saline water: the concentration increases from about 70,000 mg/kg at the top to 250,000 mg/kg at the bottom. The source of this saline water is the waste water from the desalting complex. The solar pond can be used to generate electricity and becomes a permanent storage pond for the salt originally contained in the drainage water. If the cost of the resulting desalted water is comparable to that resulting from developing new water sources, the solar pond-reverse osmosis plant is a viable alternative. However, safety with regard to "permanent" salt storage near a major aqueduct and overlying groundwater would remain a major concern.

Nonpoint Source Pollution Project

This is the third in a series of articles about agricultural water pollution. The previous articles discussed (1) industry supported voluntary agricultural pollution control and (2) fertilizer as a water pollutant. "Farming and Water Quality: a Handbook for the San Joaquin River Basin by R. E. Merrill et al. (in press) addresses all these issues and will be available mid-May from Dennis Wescott, Central Valley Regional Water Quality Control Board, 3201 S. Street, Sacramento, CA 95816-7090. Or, while supplies last, it may be obtained from your local Cooperative Extension office. You, as an individual, participate in this project through evaluating your own sphere-of-influence from both an environmental as well as a traditional business viewpoint.

Figure 1

The Sacramento Bee/ Paul Duginski



Soil along nearly two-thirds of the San Luis Drain is suspected of containing selenium, blamed for deformities in waterfowl.

San Luis Drain--Schedule of Upcoming Events

J. D. Oster

1. Environmental Impact Statement--Completion of San Luis Drain to Chipps Island-Sacramento-San Joaquin Delta. The Bureau of Reclamation plans to complete this statement by November 1984.

2. Discharge Permit--Staff review and public hearing processes to be conducted by the Central Valley Water Quality Control Board may require one year.

3. Solar pond--Reverse Osmosis Plant. Operational tests of this alternative of drainage water disposal should begin about August 1984 at a pilot plant located at Los Banos according to the California Department of Water Resources.



Irrigation Efficiencies

G. R. Hanson and
W. W. Wallender

Good irrigation water management includes both proper irrigation scheduling and efficient application. Proper scheduling, a function of crop evapotranspiration, root depth, and soil type, defines the interval between irrigations and the net volume of water to be applied. An efficient irrigation, a function of irrigation system design and management, applies the net volume with minimal losses.

Definitions

Application efficiency is commonly defined as Ea = Volume of water stored in the root zone/Volume of water applied to the field. However, by this definition, efficiencies of 100 percent are attainable by severe underirrigation, which is undesirable. Thus, not only should efficiency be considered but also adequacy of the irrigation.

An adequate irrigation supplies sufficient water to the root zone throughout most of the field. System design is frequently based on about 80 percent of the field receiving at least the desired net volume of water.

A definition that considers both adequacy and efficiency is irrigation efficiency: Ei = Volume of irrigation water required by crop/Volume of water applied. The volume of irrigation water required by the crop may include not only evapotranspiration needs but also leaching requirements to control soil salinity. The volume may be less

than the crop evapotranspiration when rainfall or upward flow from a shallow water table contribute significantly to the crop needs.

An adequate but efficient irrigation requires high uniformity of application. Uniformity describes the evenness of the depth applied throughout the field. A 100% uniformity means the same depth was applied at all locations. Measurements of uniformity include distribution uniformity (DU), frequently used for surface irrigation systems, and Christiansen coefficient of uniformity (CU), frequently used for sprinkler irrigation systems, where DU = Average low quarter depth of water infiltrated/Average depth infiltrated, and CU = Average depth infiltrated minus average deviation from average depth/Average depth infiltrated. The average low quarter depth is the average value of the lowest one fourth of the measured values, each value representing an equal area of the field.

A close relationship exists between uniformity, irrigation system management, and irrigation efficiency. High uniformity results in small differences in the volume of water infiltrated throughout the field. Thus, by not overirrigating, high efficiencies can exist. However, low uniformities result in large differences infiltrated throughout the field. High efficiencies then, will be found only if underirrigation occurs through most of the field.

Factors Affecting Irrigation Efficiency

Surface Irrigation Systems. Uniformity of application depends on the rate of water advance across the field, i.e. fast advance rates result in high uniformity. The advance is affected by soil infiltration rate, surface roughness (including crop effects), inflow rate, slope of the field and length of run.

Primary losses in surface irrigation include surface runoff and deep percolation. Deep percolation losses can be minimized by high uniformity and proper management. Runoff losses can be minimized by tailwater recovery systems of cutback of inflow rate (not practical in many cases).

Sprinkler Systems. Uniformity depends on sprinkler head/nozzle characteristics, wind speed, pressure, and spacings along laterals and mainlines. Pressure losses along laterals and mainlines should also be considered since excessive losses cause nonuniform application of water along a lateral.

Water losses from sprinkler systems include evaporation, wind drift, deep percolation, and sometimes runoff. Evaporation losses of 10% are common but may exceed 20-30 percent of the applied water. Runoff losses occur where the application rate exceeds the soil infiltration rate.

Trickle Irrigation Systems. High uniformity requires minimizing pressure losses along laterals and mainlines and maintaining emitters to prevent clogging. Emitter variation due to manufacturer processes can cause some nonuniformity. Losses are mainly deep percolation.

Irrigation System Selection and Efficiency

No one irrigation system is universally more efficient than others. All systems, properly designed and properly managed, can obtain high efficiencies. Proper design involves matching the system to the site conditions. Proper management involves applying only the needed volume of water. Table 1 contains guidelines to be used in system selection. Table 2 lists some measured irrigation efficiencies and the practical attainable efficiencies.

Table 2. Measured and practical efficiencies.

System	Measured*	Practical**
Furrow	24-77%	70-85%
Graded borders	56-100%	70-85%
Basins (level)	85-100%	75-90%
Sprinklers	60-90%	70-80%
Drip	-	70-85%

*Kruse, E. G. and D. F. Heerman. 1977. Implications of irrigation system efficiencies. Journal of Soil and Water Conservation Vol. 32 (5).

**Dickey, G. L. 1980. Irrigation water management and system selection. Presented at the 30th Annual Southwest Regional Appraisal Conference of the American Institute of Real Estate Appraisers, San Francisco.

Table 1

Factors to Consider in Selecting an Irrigation System[1]
(Limitations of Systems)

	SPRINKLER SYSTEMS				SURFACE-FLOOD SYSTEMS			
FACTORS TO CONSIDER	Portable	Wheel Roll	Solid Set	Center Pivot	Graded Border	Level Border	Furrow	DRIP SYSTEMS
Slope limitations:								
Direction of irrigation	20%	15%	none	15%	0.5%-4.9%	level	3%	none
Cross-slope	20%	15%	none	15%	0.2%	0.2%	6%	none
Soil limitations;								
Intake rate (in./hr.)								
Minimum	0.10	0.10	0.05	0.30	0.30	0.1	0.1	0.02
Maximum	none	none	none	none	2.0	0.2	3.0	none
Water capacity in root zone (inches)	3.0	3.0	none	2.0	6.0	6.0	4.0	none
Depth	none	none	none	none	enough for needed grading			none
Erosion hazard	slight	slight	slight	mod.	mod.	slight	severe	none
Saline-alkali soils	slight	slight	slight	slight	mod.	slight	severe	mod.
Water limitations:								
Total dissolved solids (TDS)	severe	severe	severe	severe	slight	slight	mod.	slight
Suspended solids	mod.	mod.	mod.	mod.	none	none	none	severe
Rate of flow	low	low	low	high	mod.	mod.	mod.	low
Climatic factors:								
Temperature control	no	no	yes	no	yes	yes	yes	no
Wind affected	yes	yes	yes	yes	no	no	no	no
Adaptability to all crops	good	good	good	fair	v.good	v.good	v.good	good
Systems Costs: (1981 data)								
Capital cost ($/acre)	650-1000	650-1000	1100-1900	1100-1600	800-1000	500-600	650-800	800-1900
Labor cost[2]	high	mod.	low	low	mod.	mod.	high	low
Power cost[3]	high	high	high	high	low	low	low	mod.
Average annual cost ($/ac/yr)[4]	100-200	100-200	200-300	200-300	100-200	100-200	200-300	200-300

1. Dickey, G. L. 1980. Irrigation water management and system selection. Presented at the 30th Annual Southwest Regional Appraisal Conference of the American Institute of Real Estate Appraisers, San Francisco.
2. Low = less than $20/ac/yr.; moderate = $20-$50/ac/yr.; high = over $50/ac/yr.
3. Low = $0-$5/ac/yr.; moderate = $5-$15/ac/yr.; high = over $15/ac/yr.
4. Amortized capital cost plus operation and maintenance cost.

Women and Minorities in Agriculture

Martha Conaway and
J. D. Oster

The number of women and minority individuals has increased steadily in the ranks of college enrollees and graduates over the past decade. This article reports statistics related to female and minority degree recipients in the agricultural sciences, and briefly discusses the implications for Cooperative Extension.

Perhaps the implications for Extension should be pointed out first. Our organization has a commitment to affirmative action in hiring, and the delivery of its programs. Affirmative action does not just mean "nondiscrimination." It begins with the identification and quantification of minority and other potential recipients of our services. Then, we must plan and implement measures to encourage and maintain participation in our programs by the people we have identified.

Appreciating the changing composition of graduates in agriculture is important. They are potential Cooperative Extension staff, present and future clients. We must insure that our actions are in harmony with the changing composition of the graduate pool.

The progress of women in agricultural sciences in the USA was documented in a recent article by Collins and Pesek (1983). The crux of the article is that the number of women studying agricultural sciences has increased significantly in the past decade, but there is a disproportionately low number of women employed in agriculture with the federal government and college faculties. Their statistics, shown in Table 1, illustrate the large increase in the number of female agronomy (crop and soil science) graduates in the USA between 1976 and 1980. The authors note that more progress in recruiting qualified women for jobs, and providing professional role models is required to close the gap between the numbers of women educated in agriculture and those finding agricultural careers.

What is the situation in California? California and national data for ethnicity and gender are similar. For the broad category, agriculture and national resources, the percentage of bachelor's and master's degrees received by nonwhite ethnic groups ranged from 0.5% to 5.7% (Table 2). Asians receiving bachelor's degrees in California had the highest percentage (5.7). This compares to 1.2% for the U.S. In other categories, the differences between California and national data are 1.1% or less.

Data by specific subject fields are available for gender (Table 3). For crops, the California and national for bachelor's degrees received by women are nearly the same (14% vs 16%). For soils, women account for 20% of the bachelor's degrees in California as compared to 26% on a national basis. In general agriculture, women received 25% of the bachelor's degree in California as compared to 19% on the national level. As with minorities (Table 2), the percentage of master's degrees awarded to women was less than for the bachelor's degree. This seems to be a logi-

cal consequence of the time required to obtain advanced degrees and the recent increased interest by women in receiving degrees in agriculture. However, the difference could persist if women or ethnic minorities are not encouraged to do advanced work.

Perhaps more dramatic are the statistics that show changes in the number of agriculture degrees awarded to men, women, and minorities from all California colleges from 1976-77 to 1980-81. In 1976-77 the percentages of bachelor's and master's degrees awarded to women were 27 and 15, respectively. The corresponding numbers for bachelor's and master's degrees in 1980-81 were 36 and 25, or about an increase of 10% in four years. Changes in minority percentages for the same time interval were more modest. The percentages of bachelor's and master's degrees in 1976-77 awarded to Black, Hispanic, and Native Americans were 4.6 and 2.9%; the corresponding numbers for 1980-81 were 9.3 and 6.8%. As can be seen from these numbers, there has been a large increase in the number of women with agriculture degrees and only a modest increase in minority numbers.

You may be interested in the composition of our academic staff (UCCE) in some of the agricultural subject areas. This data is current as of February 20, 1983. The statistics listed in Table 4 are for the following discipline areas: Agronomy and Range, Soils and Agricultural Engineering, Pomology, Environmental Horticulture, Subtropical Horticulture, Entomology, Pest Management, Plant Pathology, Weed Science, and Vegetable Crops.

References

1. California Postsecondary Education Commission. Major Gains and Losses: Recent Shifts in Popularity of Academic Disciplines as Fields of Concentrations. March 1983 draft. 1020 12th St. Sacramento, California.

2. Chapa, Jorge. UC Cooperative Extension Affirmative Action office. Personal correspondence. November 17, 1983.

3. Collins, M.E. and John Pesek. 1983. Women in Agricultural Sciences. Journal of Agronomic Education. Vol. 12, pp 87-91.

Synthetic Nitrogen

Stuart Pettygrove

What synthetic nitrogen fertilizer materials are used the most in California? Here are the percentages of the statewide total nitrogen tonnage for the most important materials in 1983.

	%
Anhydrous ammonia	21.9
32% N Urea ammonium nitrate solution	16.9
Aqua ammonia	9.6
Urea	8.8
Ammonium sulfate	6.7
Ammonium nitrate	5.5
20% N Ammonium nitrate solution	4.1
All others	26.4
Total	100.0

= 487,736 tons of N

(Source: Fertilizing Materials--Tonnage Report, California Department of Food and Agriculture.)

Table 1. Number of males and female agronomy graduates in USA*

Year	B. S.			M.S./M. Agric.			Ph.D.		
	M	F	%F	M	F	%F	M	F	%F
1976-1977	783	111	12.4	204	20	8.9	84	3	3.4
1977-1978	1245	204	14.1	183	34	15.7	122	6	4.7
1978-1979	1158	203	14.9	207	34	14.1	118	6	4.8
1979-1980	930	229	19.8	247	54	17.9	94	9	8.7

*Number represents only U. S. citizens by birth.

Source: Collins and Pesek

Table 2. Number of Degree Recipients for Discipline Areas by Race, Spanish Origin (Hispanic), California and the Nation, 1975-76, 1976-77, 1978-79, and 1981-82 NCES Data Tapes

	Agriculture and Natural Resources							
	California				Nation			
	B.A.	%	M.A.	%	B.A.	%	M.A.	%
Black	62	.8	10	1.1	2,604	1.5	560	2.2
American Indian	101	1.3	3	.3	858	.5	58	.2
Asian	441	5.7	48	5.4	2,095	1.2	1,170	4.6
Hispanic	201	2.6	20	2.2	1,922	1.1	409	1.6
White	6,855	89.4	799	90.8	160,937	95.5	23,148	91.3

Table 3. Number of Degree Recipients in Specified Subject Fields 1975-76, 1976-77, 1978-79, and 1981-82, National Center for Educational Statistics Data Tapes

	California					
	B.A.			M.A.		
Agriculture & Natural Resources	M	F	%	M	F	%
Agriculture, general	1,083	365	25	393	71	15
Agronomy, crops	194	31	14	36	3	8
Soil Science	191	47	20	58	9	13
	National					
Agriculture, general	12,329	2,896	19	2,350	382	14
Agronomy, crops	9,474	1,831	16	2,816	425	13
Soil Science	3,248	1,180	26	976	154	14

Source: Chapa

Table 4. Cooperative Extension Academic Staff in Selected Agricultural Subject Areas (as of 2-20-83)

	Specialists	%	Farm Advisors	%
Total	88	98	119	96
Male	86	2	114	4
Female	2	2	5	4
Minority	2	2	5	4

(Source: Cooperative Extension Affirmative Action Office)

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