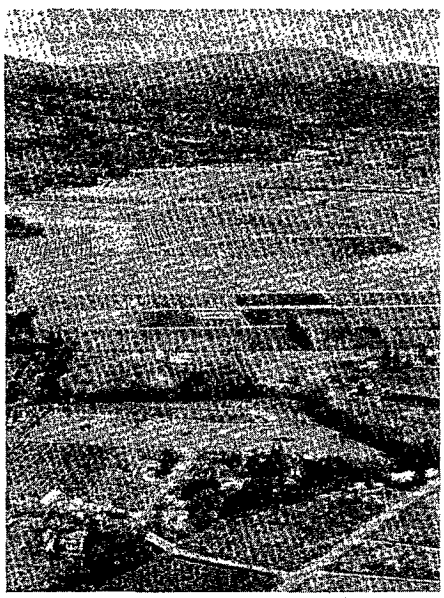
Fertilizer Research and Education Program

A Progress Report 1990-92

California Department of
Food and Agriculture

Fertilizer Research and Education Program



A Progress Report 1990-92

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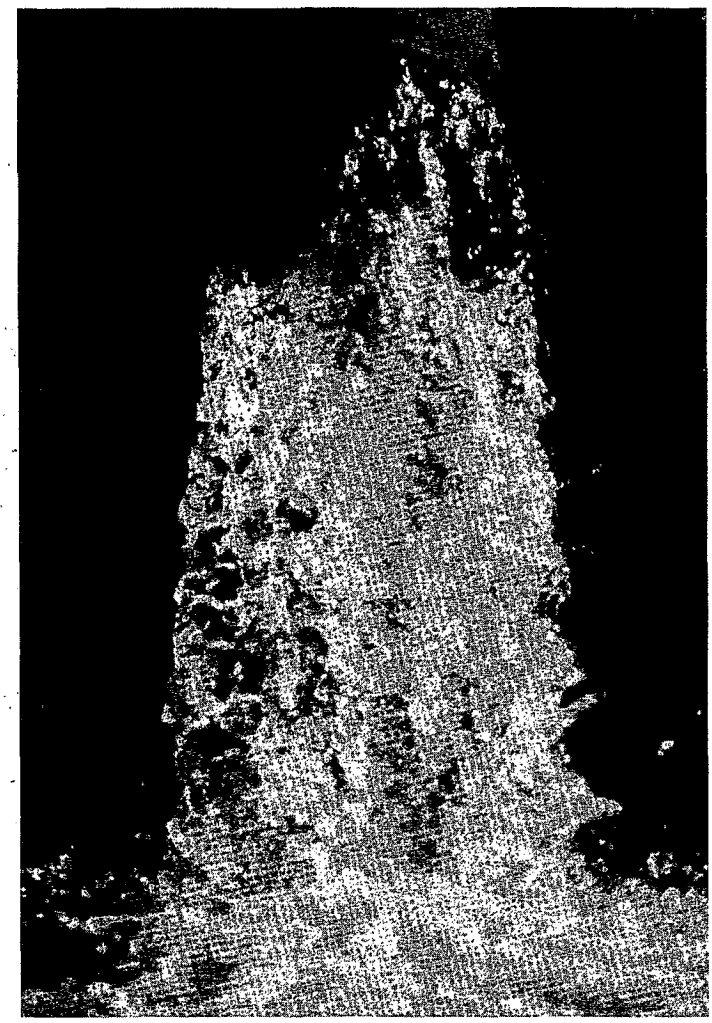

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Introduction

In 1990, the Fertilizer Research and Education Program was created to address the increasing levels of nitrate contamination in groundwater throughout California.

If anything has been constant in the last few years it is change. Society's past goal for agriculture has been the production of abundant food at reasonable prices. The joint effort and creativity of California growers, researchers, support industries and government have delivered outstanding results. Now, however, society is placing new demands on our growers: the production of abundant food and fiber while maintaining the integrity of natural resources and the environment. This new goal makes sense because we have the responsibility to safeguard for future generations the renewable bounty that supports us all. From a practical standpoint it is much easier to prevent damage to our natural resources than to restore it.

This responsibility poses many challenges and opportunities for everybody. I am convinced we can enhance the environmental performance of our agricultural production and maintain its economic viability. As a matter of fact, I believe that improved stewardship of resources will become a requirement to remain viable in the competitive agricultural production sector.

Therefore we need to work with all parties to show that we can improve and enhance our land and water resources. If we fail, regulation will come. When and how is unknown, but it does not look encouraging from the experience of growers in other states such as Arizona and Nebraska. We, in agriculture, are and should continue to be part of the solution. We recognize the complexity of the situation but would rather develop solutions that fit farming constraints than have others tell us how to farm.

Growers care and have a vested interest in maintaining the viability of the resources that make farming possible and so successful here in California. We at the California Department of Food and Agriculture are part of that team effort.

Henry Voss, Director

California Department of Food and Agriculture

Acknowledgements

A great many people deserve recognition for their assistance, insight, and support in the process of developing the Fertilizer Research and Education Program (FREP), including growers, the fertilizer industry, government officials, university people, and individuals concerned about the future of California.

Many people from the California Department of Food and Agriculture (CDFA) saw this program develop from its infancy and provided their full support and insight. We owe tremendous thanks to Vashek Cervinka of the Agricultural Resources Branch and Steve Wong of the Feed, Fertilizer and Livestock Drugs Branch. We would also like to acknowledge the efforts of Ezio Delfino, retired Assistant Director of Inspection Services, Bob Wynn, Assistant Director of Inspection Services, A.J. Yates, Deputy Director, and Bill Tracy, former Deputy Director, for their ongoing support and assistance.

Dr. Stuart Pettygrove of the Land, Air and Water Resources Department at the University of California Davis served on the Nitrate Working Group, advised the Research Subcommittee, and provided valuable input and generous assistance in the early stages of FREP's development. Casey Walsh Cady is providing invaluable assistance and dedicated service in carrying out many of the activities required to keep the program going. Natalie Clohossey, Steve Shaffer, Merry Wells and Barbara Elliott, (currently with USDA), also provide ongoing assistance and support.

Special recognition goes to Jill Auburn, Carl Bruice, Bob Dickens, Al Ludwick, Steve Purcell, Wynette Sills, Brock Taylor and Charles Tyson, members of the Research Subcommittee and to all the members of the Fertilizer Inspection Advisory Board. Their dedication, insight and professionalism have been invaluable in helping us select quality projects for the program. *(Please refer to Appendix 2).*

We also greatly value the input and support received from Steve Beckley and the staff at the California Fertilizer Association, Jim Thorup who served on the Research Subcommittee, and Richard Weaver, former chairman of the Fertilizer Inspection Advisory Board.

Stan Buscombe, Matt Reeve, Gwen Cristoni and the staff at CDFA's Feed, Fertilizer and Livestock Drugs Branch; Carl DeWing and Tom Biondi of the Communications Office as well as Mark Pepple and John Troiano of the Department of Pesticide Regulation also provided valuable assistance. Others deserving mention include the project leaders and cooperators as well as the dozens of professionals who reviewed project proposals.

This program owes thanks to many people from outside the department who provided input and advice. We are grateful to Dean Schnaible, David Cohen, Eliseo Samaniego, Jack Hodges, Tom Howard, Stan Martinson and Manucher Alemi from the State Water Resources Control Board; Greg Smith, Arturo Carvajal, Baryohay Davidoff and Jonas Minton from the Department of Water Resources; and Ricardo Amon, Charles Brush, Tony Wong and Henry Traylor from the California Energy Commission. Neil Dubrovsky from the United States Geological Survey and Dennis Westcott, Jim Rohrbach, and Angela Carpenter from the Regional Water Quality Control Boards all provided valuable consultation as did Jerry Snow and Matt Zidar from the Monterey County Water Resources Agency. We would also like to thank Kurt Schulbach of the Monterey County Extension Service and Steve Weinbaum, Dave Chaney, Chuck Ingels, Ken Tanji, Roland Meyer and Bill Liebhardt from the University of California-Davis.

Special recognition goes to Ray Coppock who assisted us in writing this report. Photo credits go to the Department of Water Resources, the California Foundation for Agriculture in the Classroom and CDFA. Many other people reviewed draft sections of this report or contributed information or insight in the process. Any errors of omission or fact remain our responsibility. Finally we would like to acknowledge the outstanding work of Judy Lawrence and her team in the design of this report.

Jacques Franco
Program Coordinator, Fertilizer Research and Education Program

Table of Contents

Introduction i

Acknowledgements ii

Overview 1

Background 1

The Nature of the Nitrate Problem 2

CDFA Nitrate Working Group Report 4

Criteria for Nitrate Sensitive Areas 5

First Projects 7

The Competitive Grants Program 9

Public Service & Outreach 11

Outlook 12

Appendices

1- Project Summaries 15

2- Advisory Boards 24

3- Selected References 28

4- Acreage & Fertilizer Use of High Priority Crops in California (1990) 30

5- FREP Materials & Information Request Form 31

In the News

Speakers Swap Philosoph... Struggles, and Success... at NGA Ground Wa...

North Dakota Governor... off Three-Day Meeting... Federal Roles in Gro...

States must take respons... protecting ground... initiating conservatio... and pollution preve...

Fertilizers, Environmental Concerns Spur Development of 'Best Management Practices'

BY DON DALE

Though fertilizer industry officials say there's nothing much new going on, they all appear concerned about environmental subjects being raised all over the county.

"Our industry is quite concerned about pressures from environmentalists or whoever," says Burle Ullom, executive vice president of the Arizona Agricultural Chemicals Association. Nitrates are the hot regulatory agencies... the cry. "There'... general," ...ore

Best management practices are important for growers to understand, because they are potentially the solution to the environment ills that... caused by nitr... other potent... agricult...

a good job of nitrogen and irrigation management overall to do a good job of minimizing non-source point pollution," Doerge says. Although enactment of the stringent laws dealing with water quality may be ... comin... of

Funds available for research

Any indivi... for part of ... research pr... programs.

The mone... increase in t... following the ... Assembly Bill...

The Fertil... Education Pro... funding—$30,... project—for:

- water-mana... related to nitrog... and the reductio... contamination.
- fertilization/n... means of determin... levels at fertilizer f...
- Proposition 6... employee/customer ... jects; and educatio... information projects.

To ... ap... ato... of ... 683... Assc... he ca... filling...

WATER: Making the Most of It

Innovative Irrigation Techniques Combine with Traditional Methods to Boost Water Efficiencies

Despite the miracle rains of March, 1991 marked California's driest winter of the present five year drought. With many growers struggling to produce tomatoes on as little as 25 percent of their normal water costs, the California Tomato Grower spoke with agronomist Brock Taylor of Vaquero Farms in Brentwood about water and fertilizer management, Taylor has an established reputation for employing innovative irrigation practices and combinations to ensure optimal yield potential with maximum water utilization.

season, following lay-by. Taylor discusses the merits and difficulties ...iated with three types of ...stems during stand ...

NITRATE DEBATE

Concern over nitrates in groundwater has Salinas Valley, California considering soluti...

BY CAROLINE MUFFORD

Nitrogen, as every dealer knows, is essential to food and fiber production (to say nothing of profits), yet it is also a potential source of environmental stress. In some cases this stress can increase drought conditions. Mini... leakage from the crop ...oiding over... is the

reassurance that ... production agricultu... contaminate water. ... ConAgra Technolog... Neogen Corpo... introduced the Ag... test to allow ... determine the ni... water. A simp... drinking, well ... well as wate... tile drainag... ...st cal...

Getting the word out about fertilizer improvements

In an effort to get the word out to all those involved with production agriculture about the advancements being made in the use of fertilizers and the ability to reduce potential groundwater contamination due to fertilizer use, the California Department of Food and Agriculture's Fertilizer Research and Education Program will hold a one-day conference to update the public on project progress on Oct. 22 at the University of California, Davis.

The key-note speaker of the conference, Dr. Roland Hauck, senior scientist at the National Fertilizer and Environment Research Center in Muscle Shoales, Alabama, will give a national perspective on nitrate in groundwater issue including information on current legislation and government involvement concerning nitrate.

The conference will also feature ...

...ows: Initially used ...977 drought, false ... the water closer to ..., about two to three ..., versus the 10 to 12 ...ance permitted by ... furrow irrigation. ...y useful for shallow ...h in which seep moisture i ...cessary, Taylor says th ...rrow irrigation is especia ...ar among growers in ...islands.

...he traditional farming sit... double row tomatoes is ... ...acing. False furrows are ...itially to minimize the ar... water required for ... establishment. The proxir... irrigation furrow allows ...mitted much closer

D-039594

Overview

Background

Nitrate contamination of groundwater is a widespread problem in California and part of the nitrate comes from agriculture. Some of the agricultural sources of nitrate in groundwater are the target of a program of the California Department of Food and Agriculture (CDFA) supported by the California fertilizer industry. It's called the Fertilizer Research and Education Program—FREP, for short.

FREP was created to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. Most of FREP's current work is concerned specifically with nitrate contamination of groundwater.

This work involves, first, identifying and prioritizing the most nitrate-sensitive groundwater areas in California and, second, working with public agencies, growers and industry to develop, demonstrate and promote the most effective ways to reduce nitrate contamination from agriculture.

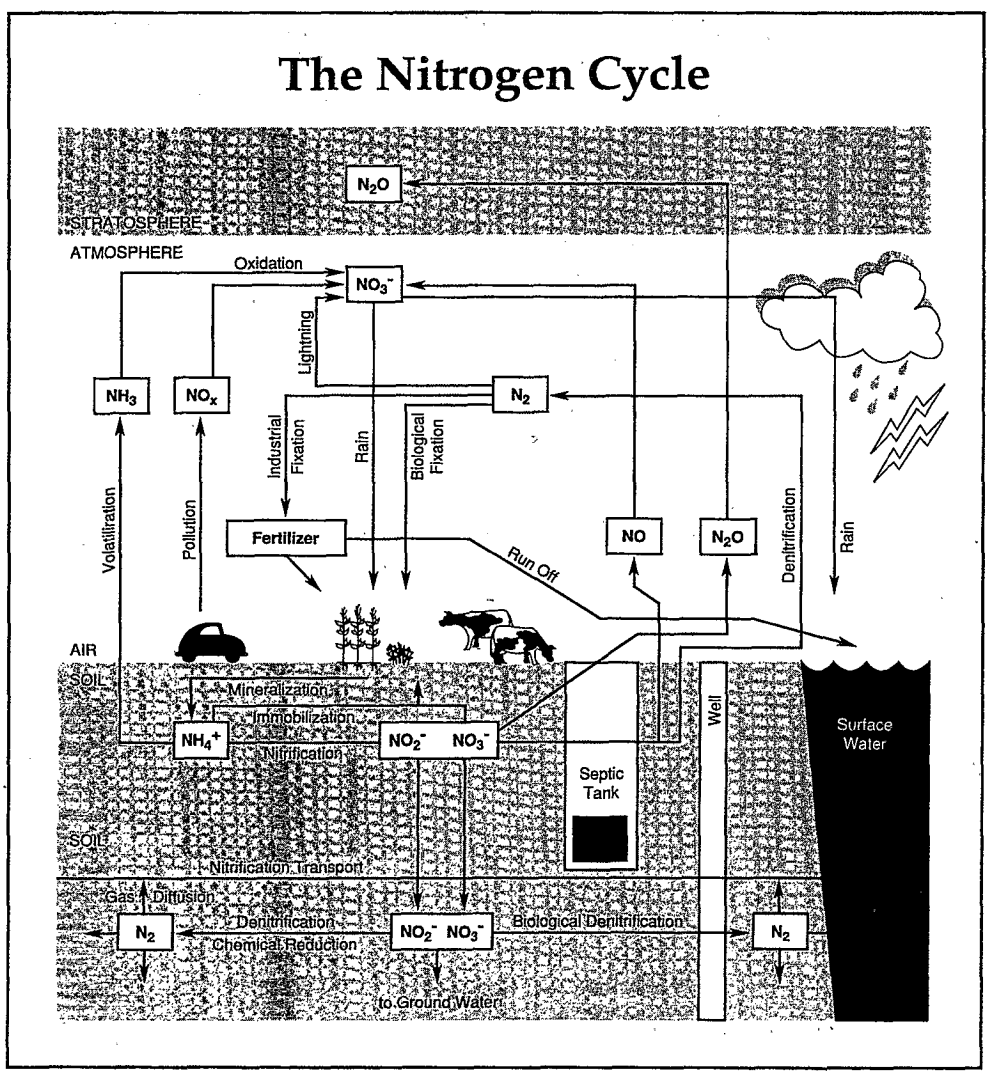
Today, FREP is participating in programs in several California farming areas where nitrate in groundwater is a significant problem. In these activities, FREP:

- Funds research to find out more about the crucial relationships among crops, irrigation methods and nitrate in the soil as well as other environmental issues related to fertilizer use such as heavy metals.
- Delivers information to growers, researchers, the agricultural supply and service industry, government officials, and the public.
- Organizes educational programs, and supports the efforts of other agencies in this area.

All this has developed out of decisions made in the late 1980's by CDFA and the California fertilizer industry about the problem of nitrate in groundwater.

The Nature of the Nitrate Problem

In recent decades, environmental monitoring has revealed widespread and steadily increasing amounts of nitrate in California's vast underground water resource. The trend is associated with a growing population and with more intensive agriculture. Rising nitrate levels in groundwater are known to result from (1) manure generated by concentrated animal production; (2) fertilizer applied to crops and landscapes; (3) septic systems and sewage treatment plants; and (4) fuel combustion and industrial sources. All of these human activities produce nitrate, which is a soluble compound of nitrogen and oxygen. Nitrate also comes from natural sources – sediments and rocks, and natural fixation of nitrogen by plants and lightning. Nitrate can move with water down through the soil to enter the groundwater supply.



Adapted from: EPA Nitrogen Action Plan, March 1991 draft

Although nitrate is a natural component of living systems, too much nitrate can cause problems – for human health and for the environment. One well-known potential threat is the relationship between high nitrate levels in drinking water and a rare infant disease called methemoglobinemia (blue-baby syndrome). In the stomachs of very young babies that have not yet developed normal acidity, nitrate can change to a related compound (nitrite) that interferes with the blood's oxygen-carrying capacity.

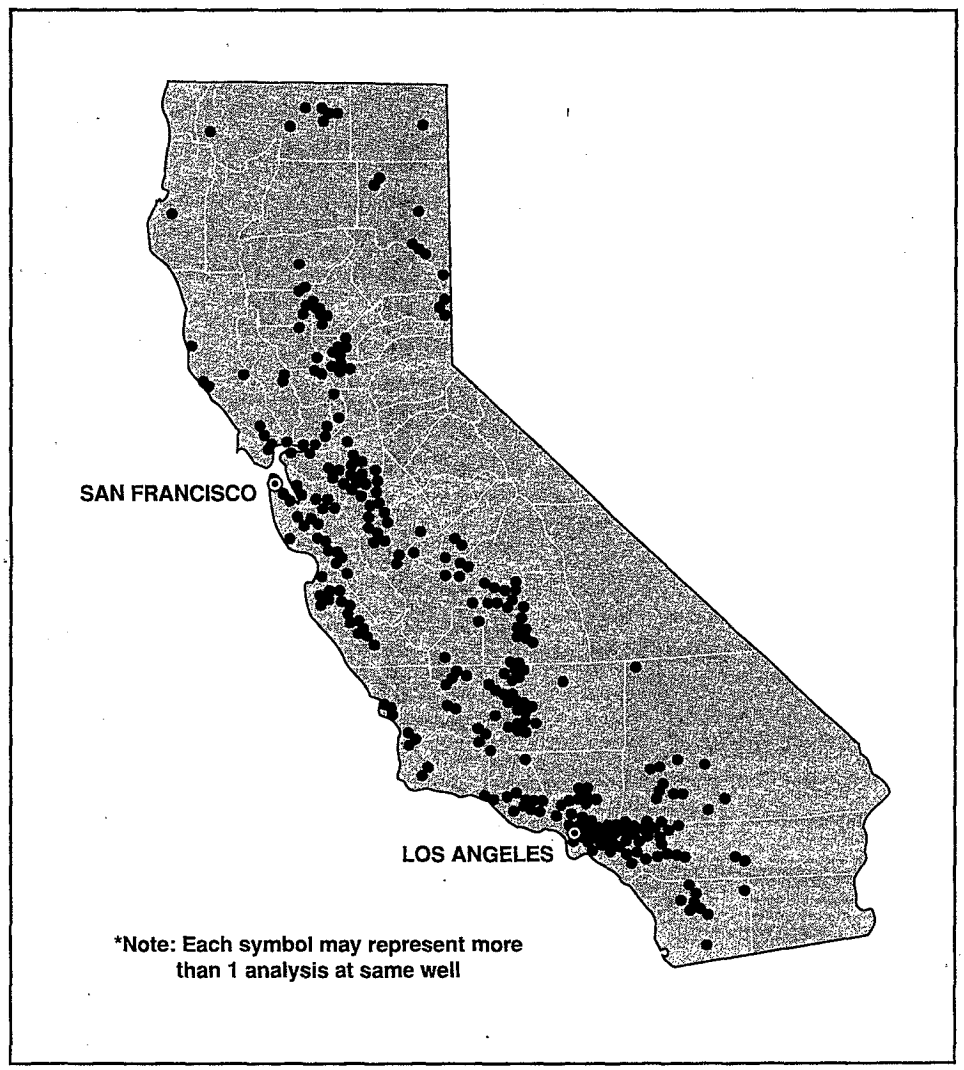
Cancer and birth defects also have been the subject of concern in relation to high nitrate drinking water, but no firm link has been established.

The current public health standard for acceptable drinking water in California is 44.3 milligrams/liter of nitrate (10 milligrams/liter of NO_3-N). *As shown on Map 1,* hundreds of wells in various areas of the state currently exceed this level.

There also is an economic dimension to the problem. When nitrate in a public water supply reaches or exceeds the 44.3 mg/l standard, costly measures are required. The well may have to be deepened or closed down, a different water source may have to be acquired for blending, or expensive water treatment may be required. For example, the Orange County Water District has estimated that wellhead nitrate treatment costs about $375 per million gallons. In 1986, public water systems in California applied to the State Department of Health Services for more than $48 million to correct nitrate violations. The total cost undoubtedly was even larger since many water agencies used other sources of funds to address the problem.

Excess nitrogen can also cause other economic and environmental problems such as oxygen-depleting algae growth in rivers and lakes, toxicity to aquatic life, increased calf abortion rates, and even loss of quality in fruit and other crops. These are often the result of inadequate manure, irrigation or fertilizer management.

Additional costs of nitrate in groundwater include land use restrictions, denial of loans for lack of a suitable water supply, and a reduced tax base. So the problem of increased nitrate levels in California's groundwater is both significant and persistent.



Map 1: Well Locations where nitrate levels have been recorded at 45 mg/l or greater during the period 1975–1987* (EPA STORET SYSTEM 1988)

CDFA Nitrate Working Group Report

In 1988, the Director of CDFA appointed a Nitrate Working Group to study the nitrate problem relating to agriculture in California. Scientists from the University of California, state agencies and industry participated. Meanwhile, the State Water Resources Control Board (SWRCB), in a report to the Legislature, reviewed the state-wide problem of nitrate in drinking water and evaluated existing programs.

The CDFA Nitrate Working Group's 1989 report, "Nitrate and Agriculture in California," also analyzed the problem on a state-wide basis. Using a computerized database that included 12 years of well testing results as well as groundwater information compiled by the SWRCB, the scientists reviewed and confirmed locations in the state where groundwater contains elevated levels of nitrate.

Their report also:

- Analyzed the mechanisms of nitrate movement through the soil. Since nitrate moves with water, the best way to slow the process is to reduce the amount of water that drains out of the crop root zone, especially percolation to groundwater.
- Reviewed the potential of fertilizer best management practices, the sources of nitrogen and the types of fertilizers, as well as application rates and methods.
- Looked at the problem of animal production in relation to nitrate pollution. Dairies, beef feedlots and poultry ranches are significant sources. Counties with most of these enterprises are San Bernardino and Riverside (the Chino area) and Imperial in the south; Merced, Stanislaus, Fresno, Kern and Tulare in the San Joaquin Valley; and Sonoma County on the coast.

The Nitrate Working Group report concluded with five recommendations. Those charges became the mission of CDFA's Nitrate Management Program (NMP), which later developed into the Fertilizer Research and Education Program (FREP). They are:

1. To identify nitrate-sensitive areas throughout California.
2. To prioritize those areas where action is most needed.
3. To organize voluntary nitrate management programs in high-priority areas in cooperation with local governments and agriculture.
4. To develop nitrate-reducing farming practices tailored to the high-priority areas and that fit into the management programs, in cooperation with growers and other government agencies.
5. To organize and support research and demonstration projects.

Criteria For Nitrate-Sensitive Areas

The first step in implementing these recommendations was to decide which locations in the state should be given highest priority. Two conditions indicate an urgent problem: First, a high level of nitrate contamination in groundwater and, second, a population that depends on that water for drinking.

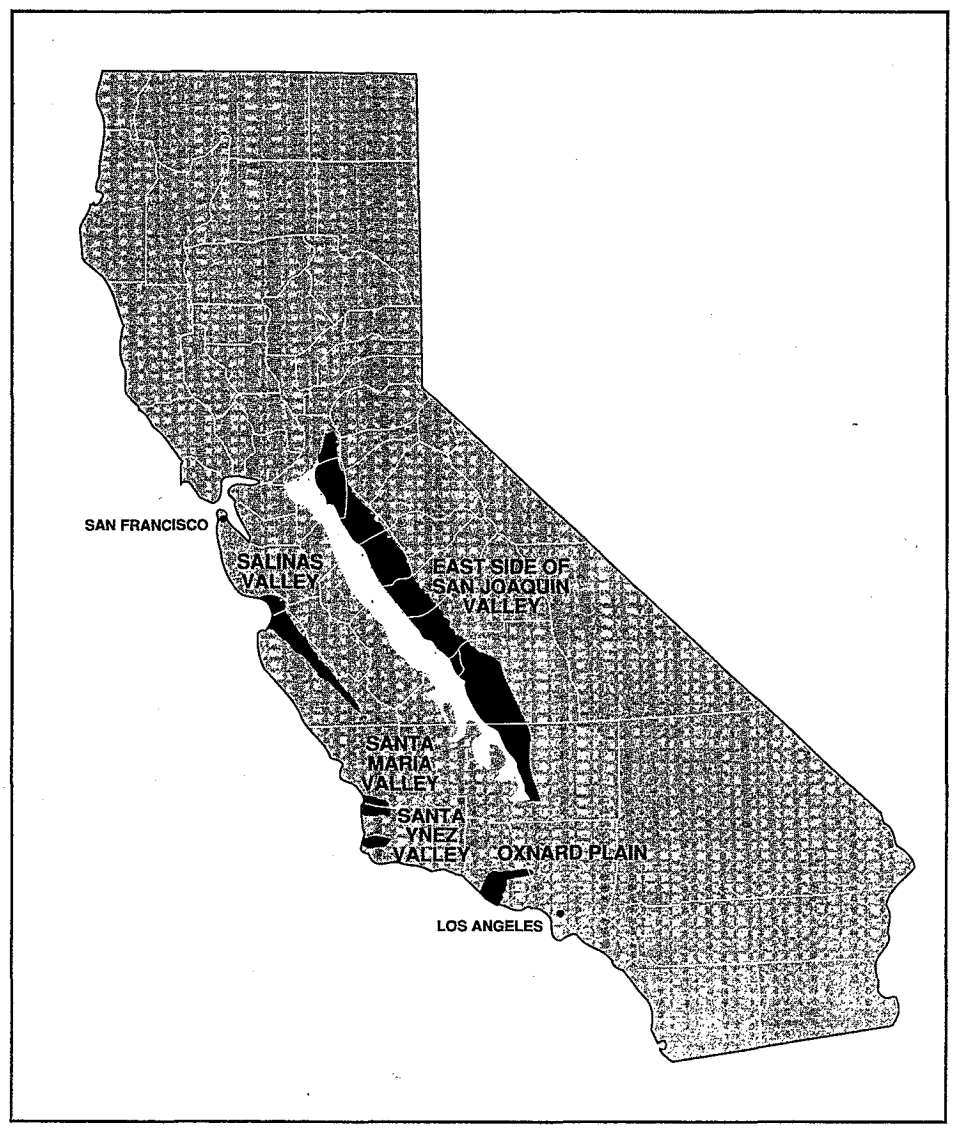
Those two conditions depend on various factors. University of California soil scientists originally listed five criteria for nitrate-sensitivity of an area:

Groundwater use. Nitrate concentration is critical if groundwater is used for domestic or animal drinking supplies. If it is used only for cleaning, cooling or irrigation of most crops, there is less concern.

Soil type. Sandy or other coarse-textured soils transmit water downward more rapidly, and nitrate with it. Also, these soils are less likely to create conditions in which nitrate turns to a gas and escapes from the soil (denitrification).

Irrigation practices. Inefficient irrigation systems that lead to large volumes of deep percolation increase the leaching of nitrate. Typically, these are surface flow systems with long irrigation runs. Well-managed sprinkler or drip systems, or surface flow systems with short runs, reduce the threat of nitrate leaching to groundwater.

Type of crop. Crops most likely to increase nitrate leaching are those that (1) need heavy nitrogen fertilization and frequent irrigation, (2) have high economic value, so the cost of fertilizer is relatively small compared to revenue produced (3) are not harmed by excess nitrogen and (4) tend to take up a smaller fraction of the nitrogen applied. Many vegetable, fruit, nut and nursery crops fit these criteria, and therefore have more potential for nitrate leaching. Those with less potential include field crops such as alfalfa, wheat and sugar beets.



Map 2: Generalized Map of Nitrate Sensitive Areas in California

Climate. High total rainfall, concentrated heavy rains and mild temperatures lead to more leaching of nitrates.

Two more criteria for nitrate-sensitivity were developed by FREP:

Distance from the root zone to groundwater. Less distance means a more immediate problem.

Potential impact. This depends on such factors as population density and availability of an alternate water supply.

These seven factors — groundwater use, soil and crop type, irrigation practices, climate, distance to groundwater, and potential impact—indicate the nitrate-sensitivity of an area. They determined where FREP's initial field activities were directed. In general, two regions of the state, the Central Coast valleys and parts of the east side of the Central Valley, fit the above criteria. *(See Map 2 on prior page).*

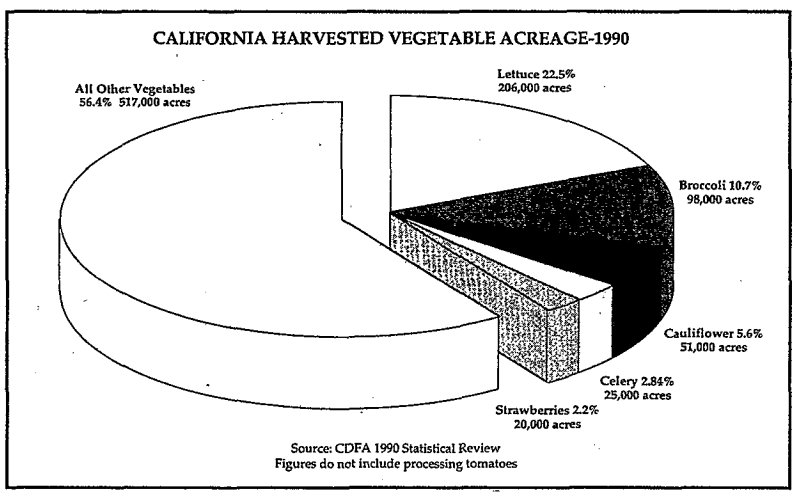


Chart 1:

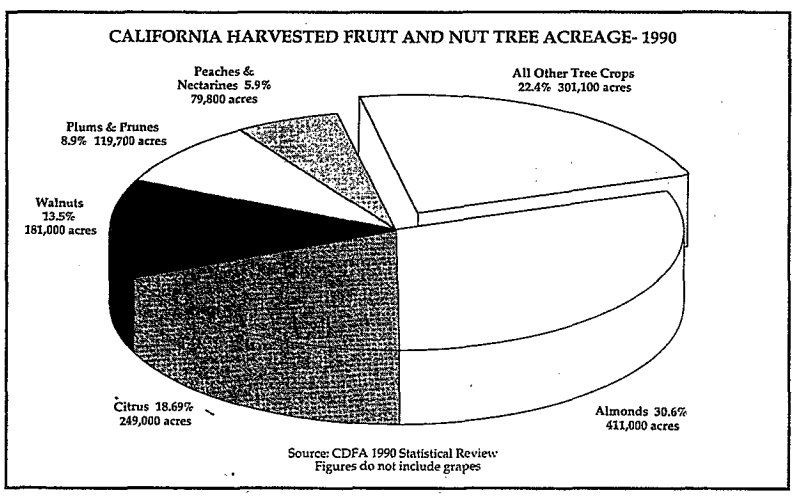


Chart 2:

The Central Coast valleys are major vegetable producing areas. In this region, irrigated vegetable fields are a potential source of groundwater contamination. The five major crops are lettuce, broccoli, cauliflower, celery and strawberries. These crops account for 43.6% of the vegetable acreage in California excluding processing tomatoes. *(See Chart 1 and Appendix 4).*

On the east side of the Central Valley, tree fruits and nuts are major crops, including almonds, walnuts, peaches and nectarines, plums and prunes, and citrus. These crops account for 77.6% of the total state fruit acreage. *(See Chart 2).* Almonds and citrus account for 8.2% of the acreage in California, yet use 12.5% of the total nitrogen fertilizer. *(See Appendix 4).*

Fruits and vegetables account for 27.9% of California harvested acreage yet use 41% of the total agricultural nitrogen fertilizer.

(The Los Angeles basin and surrounding areas where well measurements also indicate a groundwater nitrate problem are no longer a significant farming region. For that reason, FREP's agriculturally-oriented program is not very active there.)

First Projects

Using the nitrate sensitivity criteria listed above, three areas were chosen to begin FREP field activities: the Salinas Valley in Monterey County, eastern Stanislaus and Merced Counties, and the Fall River Basin in Shasta County.

In these locations, working closely with growers, local governments, industry, UC Cooperative Extension, the Soil Conservation Service and others, FREP is helping to develop improved farming practices. These improved ways of fertilizing, irrigating and managing crops are designed to fit local resource and farming conditions and reduce nitrate leaching without impairing growers' profits.

Salinas Valley

This coastal farming region, which produces more than one-fourth of the nation's fresh vegetable crops, depends almost entirely on groundwater—not only for irrigation but also for domestic and industrial water use. About 150,000 people use Salinas Valley groundwater as a drinking water source.

According to a 1987 report by the Monterey Water Management Agency, almost one half of the wells sampled in unconfined aquifers of the Valley had nitrate levels above the 44.3 mg/l standard. The report also points out that irrigated farms are currently a major source of that nitrate.

In late 1988, the Salinas Valley Nitrate Advisory Committee (NAC) was established by local authorities to develop plans to address the nitrate situation. FREP was invited to participate in this effort and helped implement a number of the committee's recommendations. With funds from the State Water Resources Control Board, the Monterey County Water Resources Agency, FREP, the lettuce industry, the federal government, UCD and UC Cooperative Extension, a number of projects are researching and demonstrating improved farming practices. These improved methods are designed not only to reduce nitrate pollution, but to promote more efficient fertilization and irrigation. Informing growers about the findings is a built-in part of these projects. *(See Appendix 1).*

San Joaquin Valley

On the eastern side of the San Joaquin Valley, particularly in Stanislaus and Merced Counties, many farming areas are particularly sensitive to groundwater contamination from nitrate. The soils tend to be sandy or coarse, with little or no layering to restrict downward water flow. The tree crops grown in this area require high inputs of nitrogen but their nitrogen uptake efficiency is relatively low. Water delivery systems tend to be less efficient, which increases deep percolation. Throughout the San Joaquin Valley, dairying, with its associated problems of manure disposal, is a large and important industry.

FREP is cooperating with a team working on a proposed demonstration project on the east side of the San Joaquin Valley to help reduce nitrate contribution to groundwater from all agricultural sources. The cooperative project will include education, technical assistance and cost-share programs for dairymen and growers. UC Cooperative Extension and USDA agencies as well as the Regional Water Quality Control Board, Western United Dairymen's Association and local governments are participating. FREP also is supporting research to develop strategies to reduce potential nitrate leaching in almonds and peaches, and to improve plant nitrogen monitoring techniques in orchards. *(See Appendix 1).*

Fall River Valley

This small farming region in northeastern California is not high in state-wide agricultural importance but was selected for a pilot project because of its small, confined aquifer and its unique combination of rural residences in close proximity to agricultural production. The Fall River Valley produces livestock, alfalfa, potatoes, grain and specialty crops such as strawberry plants. A recent survey of local wells showed that about 40 percent had nitrate levels in excess of 44.3 mg/l.

To address the problem, the Fall River Resource Conservation District is working with a multi-agency team including the Regional Water Quality Control Board, UC Cooperative Extension, FREP, local government, and the California Department of Water Resources. A project proposal was approved and funded by the State Water Resources Control Board in early 1991. In the first phase, about 20 wells throughout the region are being monitored. Information is collected not only on nitrate levels but on patterns of land use, population, agriculture and geology. Nitrate data will be correlated with proximity of leachfields, type of agriculture, soil type and depth of wells. The second part of the project is developing best management practices, primarily for potatoes and strawberries.

The Competitive Grants Program

In 1990, the state legislature authorized a tax assessment on fertilizer sales to support research and education projects to advance the environmentally safe and agronomically sound use and handling of fertilizer materials. This legislation was proposed and supported by the state's fertilizer industry and CDFA. These funds are managed by FREP in a competitive grants program.

When FREP was started, researchers already had explained much of the physical processes that occur as aquifers become contaminated with nitrate. What is needed now is specific information and practices that can be used on farms to reduce the downward flow of nitrate while maintaining productivity and the economic viability of the farms that adopt them.

The first research-oriented projects are studying:

In a drip/trickle irrigated vineyard, movement of water and nitrate through the root zone.

In a Central Valley peach orchard, the effects of eight different irrigation systems on the fate of nitrate in the soil-water system.

In almond orchards, efficiency of nitrogen fertilization, the dynamics of nitrogen movement through the system, and rates of irrigation and fertilization that contribute significant amounts of nitrate to groundwater.

In vegetable cropping systems of the Salinas Valley, (1) a comparison of drip and furrow irrigation in lettuce, (2) development of soil tests and soil moisture tests to aid fertilization decisions in drip-irrigated fields and (3) the development of winter cover-cropping methods that are compatible with vegetable crops to reduce nitrate leaching.

In a citrus orchard, the use of foliar-applied urea fertilizer to reduce nitrate pollution of groundwater and at the same time to control an important insect pest, the citrus thrip.

In various orchard crops, better techniques to monitor nitrogen levels in the plants.

Throughout the state, drip irrigation management of vegetable crops to improve use efficiency of both water and nitrogen.

In vineyards planted in heavy soils, increased efficiency of potassium and nitrogen fertilizer use, including rootstock selection, irrigation regime, and fertilizer placement.

In corn and tomato rotations, increased fertilizer use efficiency through the management of the microbial biomass by cultivation and cropping practices.

In cotton cropping systems, updated guidelines for potassium and nitrogen nutrition.

In addition, an extensive literature search is documenting the potential of site-specific crop management and real time nitrogen sensing technology to improve fertilizer use efficiency.

Education-oriented projects include:

Providing up to date soil and fertilizer management training to small and ethnic minority farmers.

Distributing information on best nitrogen-management practices for wheat growers.

Producing and distributing two videotapes – one detailing best management practices for irrigated agriculture throughout California, the other on drip irrigation and nitrogen fertigation management specifically for vegetable growers.

Developing and providing growers with the most up-to-date information on the evaluation and use of agricultural composts.

Developing and providing school teachers with educational materials on agricultural production and nutrient use by crops.

The review, selection and funding recommendations for these projects is done by the Research Subcommittee of the Fertilizer Inspection Advisory Board *(refer to Appendix 2)* which includes growers, members of the fertilizer industry, state government and University of California scientists. All proposed projects are reviewed by growers, scientists and professionals with relevant expertise. The Fertilizer Inspection Advisory Board then recommends to the Director which projects to fund. *(For more details on FREP projects, see Appendix 2 or call FREP).*

Public Service and Outreach

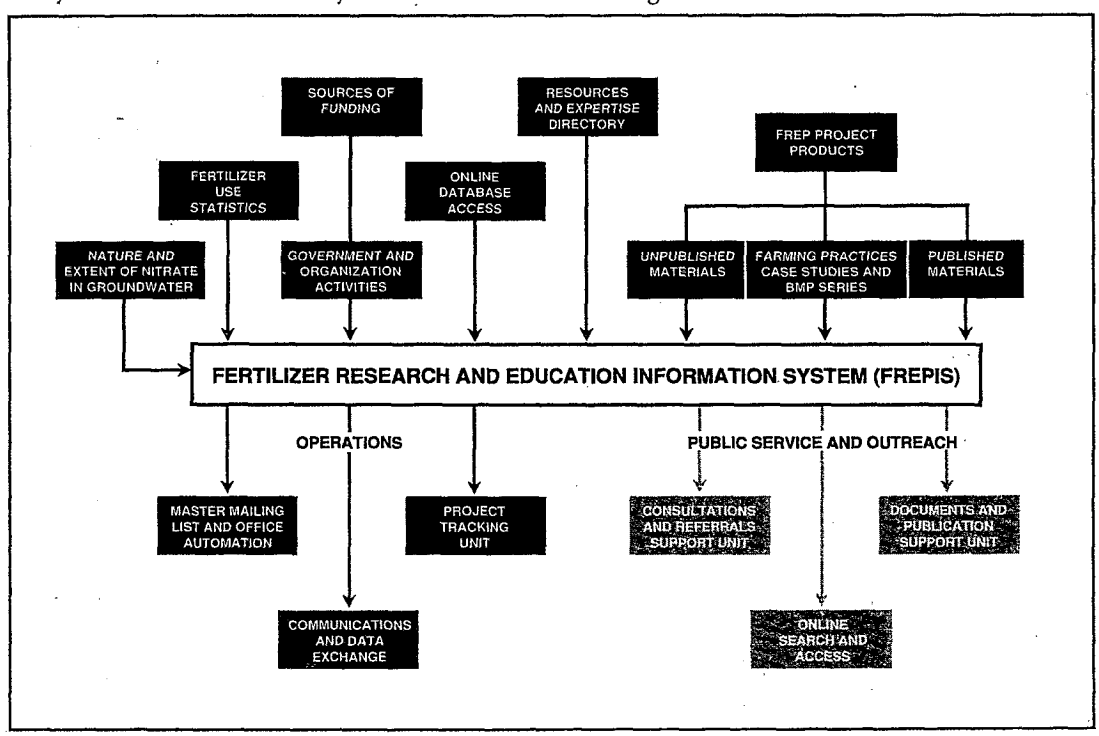
FREP also has a mission of outreach. It serves as a clearinghouse to improve information exchange among all those working on the groundwater nitrate problem in California related to fertilizer use. It facilitates access of local agencies, growers and agricultural service suppliers to federal, state and other resources. It provides technical assistance as well as funding.

FREP is developing an information system that includes (1) a computerized system to store, process and produce resource materials and publications; (2) baseline information on fertilizer use statistics and farming practices for target crops, and (3) a collection of technical articles, potential sources of funding, directories of technical expertise, and regulatory and legislative analysis and information. This system is called the Fertilizer Research and Education Program Information System (FREPIS).

Most information requests received by FREP are technical in nature and come from universities, consulting firms and other businesses, and from state and local government agencies. Information is also available to growers and the general public. FREPIS is still in its early stages of development but some of its functions are already operational. *(See Appendix 6 for information request form.)*

The FREP staff also helps organize field days, workshops and grower meetings; works with the mass media; and helps develop and distribute information on specific best management practices.

FREP also participates in an inter-agency working group that coordinates efforts to reduce non-point sources of contamination; in a University of California study team that is developing methods to assess the environmental and agronomic performance of various best management practices; and in a work group to advise the U.S. Geological Survey in its study of the extent and severity of nitrate contamination of groundwater in the San Joaquin Valley. FREP also participates in various technical advisory committees that oversee project implementation.



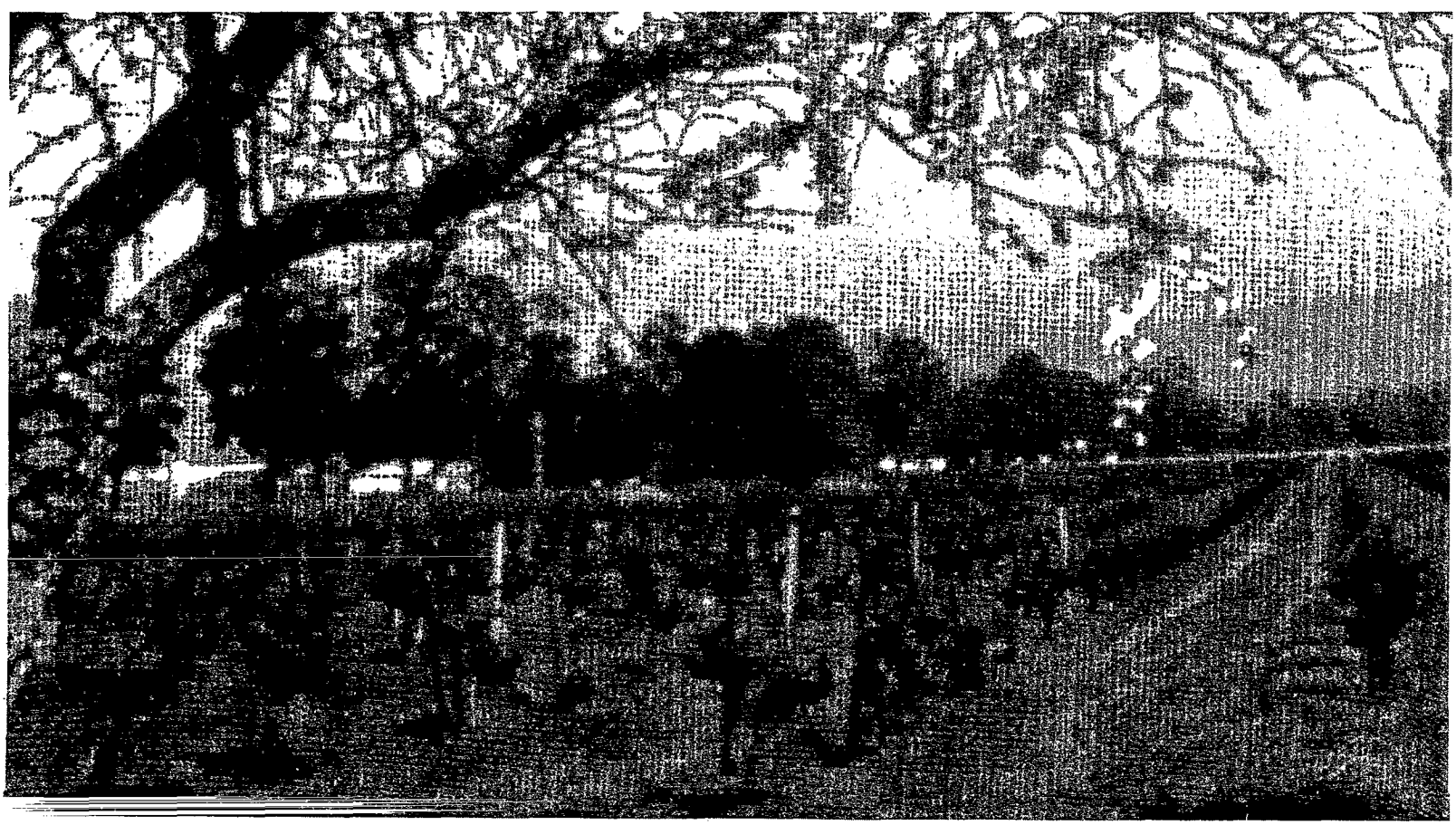
Outlook

These activities to identify nitrate-sensitive locations in California and begin the process of reducing groundwater contamination are only a first step. Continued emphasis on grower adoption of best management practices is critical. Voluntary nitrogen management programs, of course, depend on informed, concerned and cooperative growers and agricultural supply and service people. FREP recognizes that before any behavioral change takes place, they first:

- Need to become fully aware of the groundwater quality situation.
- Need to be convinced that increasing fertilizer use efficiency is to their advantage in the long run.
- Must be willing to change their practices.
- Must be free of external institutional constraints to improve practices.
- Must have the technical and financial resources to improve practices.

FREP plans to increase activities in California's Central Coast, in the Pajaro and Santa Maria valleys and the Oxnard Plain; and in the Central Valley in Fresno, Kings and Tulare counties.

The priority list will also be periodically reassessed and improved. New information will be integrated into detailed maps that indicate areas of nitrate-sensitivity throughout the state.



FREP's goals include, in addition to ongoing emphasis on inter-agency coordination and program effectiveness evaluation:

- Closer working relationships with commodity groups.
- Support for innovative research to address the nitrate problem, such as real-time nutrient sensing technology.
- Assessment of the potential risk from trace heavy metals in fertilizers, transportation and facility safety issues as well as air quality concerns related to fertilizer.
- Analysis of relative effectiveness of voluntary and regulatory approaches to address the nitrate problem.
- Increased and improved information dissemination.

Nitrate contamination of California's groundwater resource has developed over decades, and it probably will take additional decades to adequately address this situation. However, with the help of FREP and the many other cooperating parties, growers and the fertilizer industry, the process is under way.

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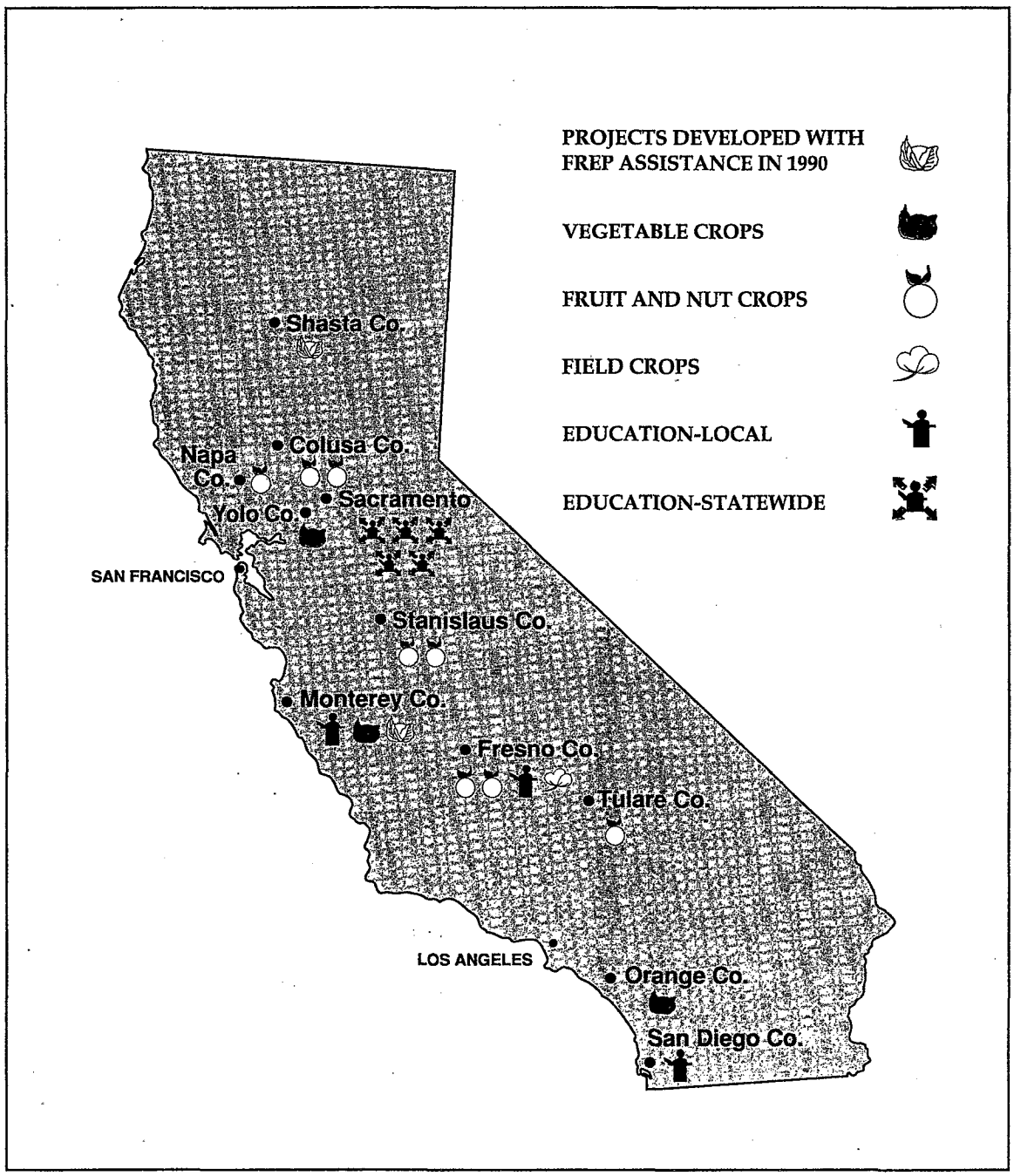


Map 3: FREP Project Sites 1990-1992

Project Summaries

Field Evaluation of Water and Nitrate Flux Through the Root Zone of a Drip/Trickle Irrigated Vineyard

Project Duration: 1991-92

Project Leader: Donald W. Grimes, UC Kearney Agricultural Center
Cooperators: L. E. Williams, Viticulture and Enology, UC Davis

The objective of this study is to determine the water and nitrate flux below the root zone of a chemigated, drip/trickle irrigated, Thompson Seedless vineyard when fertilization and added water amounts are at optimum levels. The study is being conducted at the University of California Kearney Agricultural Center located in eastern Fresno County on a 1.2 hectare field plot. Results will be published in both popular and technical journals. A field day presentation will be organized in 1993.

Nitrogen Management for Improved Wheat Yields, Grain Protein, and the Reduction of Excess Nitrogen – (A Best Management Practice for California Wheat Production)

Project Duration: 1991

Project Leader: Bonnie Fernandez, California Wheat Commission, Woodland
Cooperators: Stuart Wuest, formerly of Agronomy and Range Science, UC Davis
Kenneth Cassman, formerly of Agronomy and Range Science, UC Davis
Alan Fulton, UC Cooperative Extension, Fresno County
Lee Jackson, Agronomy and Range Science, UC Davis

This project published and distributed a descriptive brochure to provide growers with current information on managing their wheat crop for higher net returns while reducing excess nitrogen. The brochure is based on Cassman's research results. His work showed that nitrogen applied late in the growing season results in reduced excess nitrogen in the soil, lower production costs and increased farmgate value. Ten thousand brochures have been printed and distributed to wheat producers, fertilizer suppliers, UC Cooperative Extension advisors and others throughout the state.

Influence of Irrigation Management on Nitrogen Use Efficiency, Nitrate Movement and Ground Water Quality in a Peach Orchard

Project Duration: 1991-94

Project Leaders: Scott Johnson, UC Kearney Agricultural Center, Parlier
Dale Handley, UC Kearney Agricultural Center, Parlier
Cooperators: Bob Beede, UC Cooperative Extension, Kings County
Robert Carlson, Pomology, UC Davis
Claude J. Phene, USDA Water Management Laboratory, Fresno

The objectives of this project are to study soil nitrate movement under various irrigation regimes and to investigate the interaction of fertilizer use and low-volume irrigation on the yield and fruit quality of peaches. Eight irrigation treatments are being applied on a 3-acre field of O'Henry peach trees at the Kearney Agricultural Center in Fresno County. Measurements include vegetative and fruit growth, tree-water relations, nitrate movement in the soil, well water analysis and leaf nutrient analysis. The project is also conducting a grower survey on fertilization and irrigation practices in an attempt to estimate the extent of nitrate leaching under stone fruit fields. Results of this project will be presented at a grower symposium, field days and additional public meetings.

Potential Nitrate Movement Below the Root Zone in Drip Irrigated Almonds

Project Duration: 1991-94

Project Leader: Roland D. Meyer, Land, Air, Water Resources, UC Davis
Cooperators: Robert Zasoski, Land, Air, Water Resources, UC Davis
John Edstrom, Cooperative Extension-Colusa County
Nickels Soil Laboratory, Arbuckle

This project is designed to assist growers in their ability to better manage fertilizer application through drip irrigation systems. The study is investigating which rates of applied nitrogen and water might contribute significant amounts of nitrates to the groundwater in drip irrigated almonds. It is also developing recommendations for nitrogen, irrigation and soil management for use in the establishment and early maturity stages of drip irrigated almonds. This is an ongoing study that has been partially funded by the Almond Board of California but soil sampling to assess nitrate movement has only involved the lowest and highest water and nitrogen rate treatments. FREP funding will allow for the evaluation of nitrate movement under intermediate nitrogen rates at the two water levels. This study is being conducted in an orchard on the Nickels Soil Laboratory near Arbuckle. Results were presented to growers at the Annual Research Conference of the Almond Board in December, 1992.

Improvement of Nitrogen Management in Vegetable Cropping Systems in the Salinas Valley and Adjacent Areas

Project Duration: 1991-94

Project Leaders: G. Stuart Pettygrove, Land, Air, Water Resources, UC Davis
Blaine Hanson, Land, Air, Water Resources, UC Davis
Larry Schwankl, Land, Air, Water Resources, UC Davis
Kurt Schulbach, UC Cooperative Extension, Monterey County
John Inman, UC Cooperative Extension, Monterey County
Louise Jackson, Vegetable Crops, UC Davis
Richard Smith, UC Cooperative Extension, San Benito County

Cooperators: Sig Christierson and Dave Rose, Major Farms, Soledad
Pat Herbert, Herbert Farm, Hollister
State Water Resources Control Board
Monterey County Water Resource Agency
Iceberg Lettuce Research Board

The objective of this project is to develop and demonstrate management tools for vegetable growers in the Salinas Valley and adjacent areas, to reduce nitrate leaching and improve crop nitrogen use efficiency. The main components of the research include (1) a comparison of drip and furrow irrigation in a lettuce field at Major Farms, Salinas; (2) development of soil analysis and soil solution nitrate content as tools for fertilization decisions in drip-irrigated fields at Herbert Farms, Hollister, and at Major Farms; (3) and demonstration of winter cover cropping practices that are compatible with vegetable production methods in various locations in the Salinas Valley. A complete literature review and a shorter document summarizing best management practices will be published.

Nitrogen Efficiency in Drip Irrigated Almonds

Project Duration: 1991-92

Project Leader: Robert J. Zasoski, Land, Air, Water Resources, UC Davis

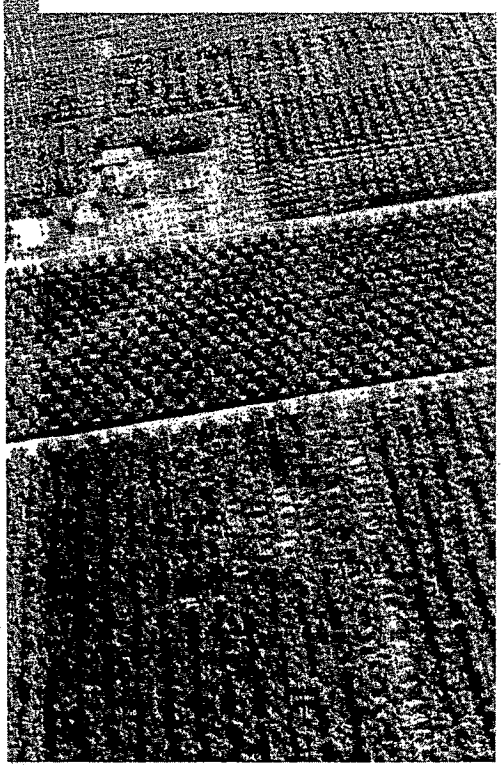
Cooperators: John Edstrom, UC Cooperative Extension, Colusa County
Dennis Rolston, Land, Air, Water Resources, UC Davis
Steve Weinbaum, Pomology, UC Davis

The project is continuing an ongoing project initially funded by the Tennessee Valley Authority (TVA) to determine nitrogen transformation and uptake in almonds under drip irrigation and acidified soil conditions. The project involves application of N^{15} depleted ammonium sulfate at 200 lbs of nitrogen per acre throughout the growing season. The project will attempt to account for the applied nitrogen in the tree, fruit and soil. Given this estimate of N-efficiency in fertigated almonds, growers will be able to better determine application rates to maximize production while limiting the potential for deep leaching of nitrate. Information will be disseminated to growers through the annual Almond Conference and by field days held at the Nickels Trust Almond Orchard in Arbuckle.

Nitrogen Fertilizer Management to Reduce Groundwater Degradation **Project Duration: 1991-94**

Project Leader: Steven Weinbaum, Pomology, UC Davis
Cooperators: Wesley Asai, UC Cooperative Extension, Stanislaus County
Patrick Brown, Pomology, UC Davis
David A. Goldhamer, UC Kearney Agricultural Center, Parlier
Dennis Rolston, Land, Air, Water Resources, UC Davis

This project is quantifying nitrate leaching as a function of nitrogen fertilizer application rates, as well as developing and publicizing best management practices to reduce the contribution of nitrogen fertilizer applications in almond orchards on coarse textured soils. A primary objective of this project is to determine the dynamics of nitrogen movement in the plant-soil-water continuum. Experiments are being conducted in two almond orchards in the nitrate sensitive region of the northern San Joaquin Valley in Stanislaus County. Outreach activities will include a summer field day in 1993, dissemination of information in county and Almond Board newsletters as well as trade journals, and presentations at grower meetings.



Optimizing Drip Irrigation Management for Improved Water and Nitrogen Use Efficiency **Project Duration: 1991-92**

Project Leader: Timothy K. Hartz, Vegetable Crops, UC Davis
Cooperators: Wayne Schrader, UC Cooperative Extension, San Diego County

The project goals are to (a) document the importance of drip irrigation/fertigation management practices on nitrate leaching losses; (b) determine the accuracy and reproducibility of field techniques to rapidly measure soil moisture as well as soil and plant tissue nitrogen levels; and (c) conduct educational programs throughout the state to improve grower competence in drip irrigation and nitrogen fertility management. Field research was conducted at the University of California South Coast Field Station in Orange County and educational events took place in the major vegetable production areas of the state.

Citrus Growers Can Reduce Nitrate Groundwater Pollution and Increase Profits

Project Duration: 1992-94

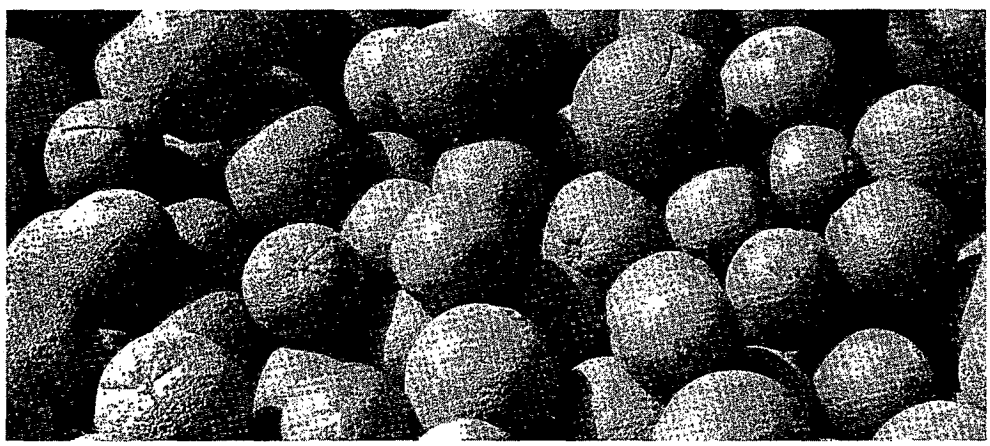
Projects Approved 1992

Project Leaders: Carol J. Lovatt, Botany and Plant Sciences, UC Riverside
Joseph G. Morse, Entomology, UC Riverside
Cooperators: Franco Bernardi, Paramount Citrus, Edison

The goal of this research is to reduce pollution of groundwater from soil-applied nitrogen fertilizer and thripicides used in citrus production. The project will provide citrus growers with optimal time and rates of foliar-urea application needed to successfully improve fruit set and yield, and control citrus thrips to reduce fruit scarring.

The project is testing the hypothesis that foliar urea applied in the April 1 to May 15 window can act as (a) a non-pesticide to control citrus thrips and reduce fruit scarring, (b) a "growth regulator" to improve fruit set and increase yield without reducing fruit size or quality and (c) a nitrogen fertilizer.

The research is using 17-year-old "Washington" navel orange trees on Troyer citrange rootstock under commercial production by Paramount Citrus in Edison, CA. Research is replicated for 2 years due to alternate bearing. Cost/benefit analysis will be developed at harvest to determine the economic impact to the grower.



Educating California's Small and Ethnic Minority Farmers – Ways to Improve Fertilizer Use Efficiency and Reduce Groundwater Contamination Through the Use of Best Management Practices (BMPs)

Project Duration: 1992-93

Project Leaders: Ron Voss, UC Small Farm Center, Davis
David Visher, UC Small Farm Center, Davis
Cooperators: Pedro Ilic, UC Cooperative Extension, Fresno County
Richard Smith, UC Cooperative Extension, San Benito County
Timothy Hartz, Vegetable Crops, UC Davis
Faustino Munoz, UC Cooperative Extension, San Diego County
Otis Wollan, Committee for Sustainable Agriculture, Colfax, CA
Tom Haller, CA Association of Family Farmers, Davis

The goal of this project is to educate small, Hispanic, and Southeast Asian farmers on ways to improve soil fertility and water use. Small and ethnic farmers who comprise the vast majority of farmers in California need access to this knowledge, yet they are not targeted by mainstream extension activities. The farmers have an acute need for this education because:

1) They tend to cluster around urban areas where groundwater contamination is more of an issue.

2) Their use of fertilizers may be less sophisticated than larger farmers.

3) The number of small farms is increasing relative to large farms.

4) Vegetables and other high value crops tend to be grown on smaller farms, and most vegetables are relatively inefficient users of fertilizers.

5) Ethnic minority farmers frequently have language and cultural barriers that require different educational methodologies.

The Small Farm Center is using the funds to augment and focus existing projects currently underway on the BMP techniques and to fund three field days per year held across the state under the auspices of Cooperative Extension.

Development of Diagnostic Measures of Tree Nitrogen-Status to Optimize Nitrogen Fertilizer Use

Project Duration: 1992-95

Project Leaders: Patrick Brown, Pomology, UC Davis
Cooperators: Steven Weinbaum, Pomology, UC Davis
Wesley Asai, UC Cooperative Extension, Stanislaus County

The goal of this project is to improve plant nitrogen monitoring techniques in orchard crops so that fertilizer applications can be better managed. This will be achieved by monitoring the concentration, composition and distribution of a range of nitrogen compounds in mature trees and relating this to plant yield, fertilizer nitrogen application and nitrate movement in the soil.

Specific objectives are to:

1) Reassess the sensitivity of currently accepted diagnostic criteria and develop more sensitive criteria of tree nitrogen status.

2) Develop plant sampling strategies to determine availability of applied nitrogen fertilizers and relate nitrogen application rates and soil testing to tree nitrogen status.

3) Develop recommendations based on soil and/or plant testing to maximize fertilizer use efficiency and reduce the contribution of orchard crops to nitrate contamination of groundwater.

Extension of results will be made via the investigators' close relation with the almond industry, the use of commercial orchards in the experiments, and presentations of results at field days and grower meetings.

Intergrating Agricultural and Fertilizer Education into California's Science Framework Curriculm (Grades K - 12)

Project Duration: 1992-94

Project Leaders: Mark Linder & Pam Emery
California Foundation for Agriculture in the Classroom
Cooperators: Bob Vice & George Gomes
California Farm Bureau Federation

The premise of this project is that with California's increasingly urban population, school children are removed from agriculture and lack knowledge of how their food is produced. The goal of this project is to provide students with a hands-on approach to increasing their agricultural literacy.

The project is providing 2,000 teachers throughout California with agricultural science curricula. Students in grades K-3 will learn that plants, in order to survive and reproduce, require certain nutrients. The 4th-8th grade unit will develop the plant nutrient concept further and show students that nutrients are required in proper forms and amounts. High school students will relate classroom science projects to current agricultural issues, including sustainable agriculture and groundwater quality.

Another aim of the project is to help promote the Foundation's efforts at state and nationwide teacher workshops and conferences. FREP funding is also helping fund publication and distribution costs associated with the Foundation's biannual newsletter.

The Use of Composts to Increase Nutrient Utilization Efficiency in Agricultural Systems and Reduce Pollution from Agricultural Activities

Project Duration: 1993-95

Project Leaders: Mark Van Horn, Student Farm, Agronomy and Range Science, UC Davis
R.E. Plant, Agronomy and Range Science, UC Davis
Cooperators: Jesus Valencia, UC Cooperative Extension, Stanislaus County
Richard Smith, UC Cooperative Extension, San Benito and Monterey Counties

The production of composts from agricultural wastes in California is increasing and many composts from non-agricultural or mixed sources are projected to be on the market as new laws promoting composting are adopted.

This project is conducting an educational program to inform the agricultural community about handling and utilizing waste products and organic amendments with an emphasis on composting. The objectives of this two year program are to educate farmers, livestock producers, industry, government and University representatives in the areas of 1) the use and evaluation of composts and manures - their advantages, disadvantages, and effects on soil properties, N dynamics, and crop growth; 2) the biological processes and effects of composting; management techniques, tools and equipment; and 3) the legal aspects of agricultural waste management, fertilization and pollution.

These objectives will be met through public presentations/workshops, in-field demonstrations, and the production of a document — all focusing on the above topics. These activities are being targeted to those areas and production systems of the state believed to be most critical in terms of agricultural nitrate pollution of ground water.

Production of a Drip Irrigation and Nitrogen Fertigation Management Videotape for California Vegetable Growers **Project Duration: 1993**

Project Leader: Timothy K. Hartz, Vegetable Crops, UC Davis

The use of drip irrigation for vegetable crop production in California is growing at an ever-increasing rate. The efficient use of drip irrigation requires management practices that are radically different from conventional furrow or sprinkler-irrigated culture with respect to water and nitrogen inputs. In recent years, significant progress has been made at the University of California and other institutions in generating field-based information on drip management practices. However, at present, there is no comprehensive reference material designed for growers, consultants and other agribusiness professionals that summarizes current knowledge on efficient management of water and nitrogen fertility with drip irrigation systems.

This project is producing an instructional videotape demonstrating the efficient management of water and nitrogen inputs for the vegetable crops which are commonly drip-irrigated. Supporting the videotape will be written reference materials providing in-depth coverage.

Establishing Updated Guidelines for Cotton Nutrition **Project Duration: 1993-96**

Project Leaders: Tom Kerby, Agronomy & Range Science, UC Davis and Cotton Research Station, Shafter, CA
Bill Weir, UC Cooperative Extension, Merced County
Bruce Roberts, UC Cooperative Extension, Kings County
Robert Miller, Diagnostic Laboratory, UC Davis
Robert Hutmacher, USDA Water Management Research Lab, Fresno
Claude Phene, USDA Water Management Research Lab, Fresno
Ray Huffaker, Agronomy & Range Science, UC Davis
Robert Travis, Agronomy & Range Science, UC Davis

Cooperators: Ron Vargas, UC Cooperative Extension, Madera County
Dan Munk, UC Cooperative Extension, Fresno County
Steve Wright, UC Cooperative Extension, Tulare County
Doug Munier, UC Cooperative Extension, Kern County

Nitrogen and potassium are both required at high levels during cotton boll development. Many cotton growers use only historical values when determining application rates for nitrogen and apply nitrogen fertilizer well in advance of the time it is required by the plant. The adoption of new, higher yielding cotton varieties throughout California require changes in plant nutrient management.

The overall goal of the project is to establish critical nitrate levels for cotton leaf growth and function; determine the feasibility of delaying nitrogen applications so that soil availability more closely corresponds to the time of demand by the plant; and improve the predictive ability of current soil potassium test procedures. New recommendations are being developed for nitrogen and potassium which simultaneously consider the soil supply rate; the quantity of nutrients stored in plant vegetative structures which can be mobilized without affecting leaf function, and the demand (timing and intensity) by developing bolls.

A Video Presentation of Best Management Practices (BMPs) for Nitrogen Fertilizer and Water Use in Irrigated Agriculture

Project Duration: 1993

Project Leaders: Larry Klaas, Agcom, Tucson, AZ
Thomas Doerge, Soil and Water Science, University of Arizona
Cooperators: Stuart Pettygrove, Land, Air and Water Resources, UC Davis

This project is producing a video to define, illustrate and promote state-of-the-art technologies for best management of nitrogen fertilizer and water use in irrigated cropping systems. The purpose of this video is to educate growers, crop consultants, farm advisors, regulatory agency personnel and the general public on the existence and importance of BMP's for nitrogen and water use in irrigated cropping systems as a means of minimizing the potential for agricultural pollution of surface and groundwater. The video will include:

1) Discussion of the role of nitrogen fertilizer and its behavior in the environment,
2) Illustrations of the seven goal-oriented BMP's currently defined for irrigated agriculture using suitable crops and locations,
3) Discussion of the nitrate sensitive areas in California including two case studies.

Crop Management for Efficient Potassium Use and Optimum Winegrape Quality

Project Duration: 1993-95

Project Leader: Mark A. Matthews,Viticulture and Enology, UC Davis
Cooperators: Zack Berkowitz, Domaine Chandon Vineyards, Yountville, CA
Jim Freisinger, Beringer Vineyards, St. Helena, CA

This project is investigating several approaches to increasing the efficiency of potassium fertilizer use efficiency of winegrapes on clay soils and evaluating whether improved vine potassium status leads to improved efficiency of nitrogen fertilizer utilization.

The objectives are testing the potential of altered fertilizer placement, altered irrigation regimes, supplemental gypsum applications, and selection of rootstocks to decrease the need for high rates of fertilizer applications. Re-evaluation of the existing criteria for vine potassium requirements is also being undertaken. Data collection includes vine potassium status, vine growth and productivity, and soil water and potassium status from a series of field trials on sites predetermined to be problem soils for potassium nutrition.

The project will culminate in a recommendation for improved potassium, and possibly nitrogen, fertilizer efficacy that will include rootstock selection, irrigation regime, and fertilizer placement.

Determination of Soil Nitrogen Content In-Situ **Project Duration: 1993**

Project Leaders: Shrini K. Upadhyaya, Biological and Agricultural Engineering, UC Davis
William J. Chancellor, Biological and Agricultural Engineering, UC Davis

"Farming by Soil" or "Site – Specific Crop Management (SSCM)" is increasingly becoming popular among agricultural scientists and engineers because of its potential to reduce production costs, increase productivity and protect the environment. Recent advances in computer technology can be used to map the variability within a field. This map along with a Global Position System (GPS) can be used to apply appropriate amounts of chemicals or some other input in real time.

This project will conduct a comprehensive literature survey to document the up-to-date progress made in SSCM, GIS (Geographic Information Systems) and sensor technology in North America, Europe and Australia. The long range objective of this study is to develop a technique to apply site-specific amounts of fertilizer in real time, based on soil fertility levels.

Impact of Microbial Processes on Efficient Use of Fertilizers from Organic and Mineral Sources **Project Duration: 1993-95**

Project Leader: Kate M. Scow, Land, Air and Water Resources, UC Davis

This project is investigating the possibility of increasing fertilizer use efficiency through the management of the microbial biomass in the soil by cultivation and cropping practices. Soil microorganisms are a significant reservoir of plant nutrients and carbon, and are responsible for the transformation of nutrients into forms available for crop uptake.

This project is addressing the use of a combination of organic sources of carbon and nitrogen and mineral sources of nitrogen to maximize availability to crops while decreasing the risk for environmental degradation from nitrate leaching.

Advisory Boards

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Beardsley & Sons
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Robert Dickens (Chair)
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Salinas

Raymond Maul
Helm Fertilizers
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David Mitts
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John Salmonson
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CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE NITRATE WORKING GROUP (1989)

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California Department of Food and Agriculture

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Agricultural Economics
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Polly Lowry
Central Valley Region
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Agricultural Resources
California Department of Food and Agriculture

Peter Stoddard
Environmental Monitoring and Pest Management
California Department of Food and Agriculture

Fertilizer Inspection Advisory Board/Research Subcommittee Members (FIAB/RS)

Jill Auburn is the information systems manager for the University of California Sustainable Agriculture Research and Education Program. She has also chaired the national Sustainable Agriculture Network coordinating committee and has participated in international sustainable agriculture networking projects. In addition, she chairs the Research and Education committee for the Organic Farming Research Foundation. Her B.A.and M.S. are from Miami University in Ohio and her Ph.D. is from the University of California-Davis.

Carl Bruice is currently an agronomist with John Taylor Fertilizers in Rio Linda. Prior to that he was the supervisor of technical services at Puregro where he coordinated technical sales support and directed the activities of the field agronomy staff. Carl received his B.A. from Humboldt State and his M.S. in Integrated Pest Management from the University of California-Riverside.

Bob Dickens is vice president and co-owner of Associated-Tagline, Inc., an agricultural supply and service firm in Salinas. Bob has been there since 1954 and is primarily involved with home and garden fertilizers. He also chairs the Fertilizer Inspection Advisory Board of the California Department of Food and Agriculture, and has been Chapter President of the California Nurserymen's Association.

Al Ludwick is the western director of the Potash and Phosphate Institute where he coordinates research and conducts educational programs in seven western states and in Mexico with the overall objective of market development of phosphorous and potassium fertilizers. He was the coordinator for Latin American programs for the Institute and a professor of Agronomy at Colorado State University for 10 years.

Steve Purcell is an agronomist with Unocal Corporation having responsibilities in research of new and established products, technical support and marketing. Steve has also worked internationally as a consultant in the Middle East and southeast Asia. Current agricultural interests include foliar plant nutrition, new product development and marketing of agricultural products. He is a graduate of the University of California-Davis.

Wynette Sills is co-owner of Pleasant Grove Farms in Sutter County, CA. where she and her husband grow rice, yellow corn, popcorn, wheat, almonds, oats and vetch. Wynette has also worked as a farm advisor for the University of California Cooperative Extension Service in Sacramento County. Wynette is interested in seeking ways in which farming can retain long-term profitability and productivity, while maintaining/improving the integrity of land, air and water resources. She received her B.S. from the University of Arizona in plant pathology and an M.S. in Integrated Pest Management from the University of California-Davis.

Brock Taylor is an agronomist with Vaquero Farms in Stockton, CA., where he directs water and fertilizer management for processing tomatoes, cotton, onions, garlic and sweet corn. He has a B.S. from Colorado State University in agronomy and is active in the California American Society of Agronomy and the San Joaquin County Agricultural Advisory Board.

Charles (Chuck) Tyson is a soil resource specialist in the State Department of Conservation's Soil Resource Protection Program. He serves as a technical resource person on soil related issues for individuals and local and state agencies. Chuck is currently promoting the implementation of the State's Soil Conservation Program and working with the USDA Soil Conservation Service to accelerate the completion of soil surveys in the state. He received his Ph.D. from the University of California-Davis in soil science with an emphasis in soil fertility and plant nutrition.

FIAB/RS and CDFA staff: Front row, L-R; Al Ludwick, Jill Auburn, Casey Walsh Cady, Wynette Sills, Steve Wong, Bob Dickens.
Back row, L-R; Carl Bruice, Jacques Franco, Charles Tyson, Steve Purcell, Brock Taylor, Vashek Cervinka, Bob Wynn.

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Acreage & Fertilizer Use of High Priority Crops In California (1990)

Fruits and Nuts

	Harvested Acreage^	Common N rate** (lbs/acre)	Total Use (Tons N)	% of Total Acreage	% of Total Harvested Acreage (cumulative)	% of Total Fruit Acreage	% of Total Fruit Acreage (cumulative)	% of Total Fruit N	% Fruit N (cumulative)	% of Total Ag N^^	% of Total Ag N (cumulative)
Almonds	411,000	198	37,108	5.1%	5.1%	30.6%	30.6%	38.3%	38.3%	8.4%	8.4%
Citrus, all	249,400	162	18,424	3.1%	8.2%	18.6%	49.2%	19.0%	57.3%	4.2%	12.5%
Walnuts	181,000	166	13,660	2.2%	10.4%	13.5%	62.7%	14.1%	71.4%	3.1%	15.6%
Plums & prunes	119,700	128	6,977	1.5%	11.9%	8.9%	71.6%	7.2%	78.6%	1.6%	17.2%
Peaches & nectarines	79,800	137	4,967	1.0%	12.9%	5.9%	77.6%	5.1%	83.7%	1.1%	18.3%
All other tree crops	301,000	115	15,784	3.7%	16.6%	22.4%	100.0%	16.3%	100.0%	3.6%	21.9%
TOTAL	**1,341,900**		**96,921**	**16.6%**						**21.9%**	

Vegetables

	Harvested Acreage^	Common N rate*** (lbs/acre)	Total Use (Tons N)	% of Total Acreage	% of Total Harvested Acreage (cumulative)	% of Total Veg. Acreage	% of Total Veg. Acreage (cumulative)	% of Total Veg. N	% Veg. N (cumulative)	% of Total Ag N^^	% of Total Ag N (cumulative)
Lettuce	206,000	174	16,345	2.5%	2.5%	22.5%	22.5%	19.3%	19.3%	3.7%	3.7%
Broccoli	98,000	206	9,206	1.2%	3.8%	10.7%	33.2%	10.8%	30.1%	2.1%	5.8%
Cauliflower	51,000	215	5,000	0.6%	4.4%	5.6%	38.7%	5.9%	36.0%	1.1%	6.9%
Celery	25,000	336	3,830	0.3%	4.7%	2.7%	41.4%	4.5%	40.5%	0.9%	7.8%
Strawberries	20,000	236	2,152	0.2%	4.9%	2.2%	43.6%	2.5%	43.1%	0.5%	8.2%
All other Vegs*	517,000	205	48,329	6.4%	11.3%	56.4%	100.0%	56.9%	100.0%	10.9%	19.1%
TOTAL	**917,000**		**84,863**	**11.3%**						**19.1%**	

^ Source: CA Dept of Food and Agriculture Statistical Review 1990

** Average of USDA Agiculture Chemical Usage 1991 Fruit Summary and FREP expert survey data

*** USDA Agriculture Chemical Usage 1990 Vegetable Summary (not adjusted for double cropping)

^Fruit figures do not include grapes ^Vegetable figures do not include processing tomatoes ^^FREP estimate

Materials & Information Request Form

Fertilizer Research and Education Program

FREP Administrative

- ☐ *"Guidelines for Proposal Preparation"*
  Fertilizer Research and Education Program, Jul, 1992, California Department of Food and Agriculture FREPA-GPP692
- ☐ *"Request for Project Suggestions"*
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FREP General

- ☐ *"FREP First Annual Conference Proceedings"*
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- ☐ *"Project Summaries"*
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- ☐ *"Nitrate Contamination of Groundwater from Fertilizer: A Review of State Programs"*
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- ☐ *"Nitrate and Agriculture in California"*
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- ☐ *"Optimizing Drip Irrigation Management for Improved Water and Nitrogen Use Efficiency"*
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- ☐ *"Demonstration Program for Reducing Nitrate Leaching through Improvements to Irrigation Efficiency and Fertilizer/Cover Crop Management– Executive Summary"*
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Nature and Extent of the Nitrate Problem

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- ☐ *"Abundant Groundwater N makes for Tricky Management"*
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- ☐ *"Nitrate Debate"*
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- ☐ *"National Pesticide Survey-Nitrate"*
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- ☐ *"Health Advisory Summary Nitrate/Nitrite"*
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Best Management Practices

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- ☐ *"Towards Optimizing Nitrogen in Walnuts"*
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- ☐ *"Regulators Crack Down on Nitrates"*
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