California Agriculture

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Nutrition research and education: Prescription for diabetes crisis

University of California | Division of Agriculture and Natural Resources | Research in Agricultural, Natural and Human Resources

Californians face weight and health care crisis


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The United States is facing a health care crisis that will only worsen if current trends in childhood and teen overweight and obesity are not reversed. National estimates from the 1999-2002 National Health and Nutrition Examination Survey reveal that more than 15% of children and teens from 6 to 19 years old are overweight. Increasing across all social and ethnic populations, rates of childhood obesity are generally highest for Latino and Native American children of both sexes and for African American girls. While some children may be more genetically susceptible to becoming overweight, all children are at risk for poor quality diets and a sedentary lifestyle.

These trends are particularly alarming because the same ethnic groups most vulnerable to obesity may also be genetically more susceptible to type 2 diabetes. Correlated with the obesity trend, rates of diabetes have increased dramatically in the past decade. The prevalence of diabetes nationwide has increased 33% in this period — and its incidence in California has increased by 67%. This increase is due in part to aging of the population, and also to improved screening and detection. In addition, type 2 diabetes, once considered "adult-onset," is now being diagnosed among children and teens.

The economic implications of these trends are profound. A report by the former U.S. Surgeon General put the economic cost of obesity in the United States at about $117 billion in 2000 — second only to tobacco as a cause of increased national health care expenditures. The current estimated direct and indirect costs of diabetes to the nation are over $105 billion annually or more than 10% of the nation's health care bill. Diabetes is a progressive, chronic, costly disease that cannot be cured, can damage almost every major organ, and can shorten the life span by an average of 10 to 15 years. The obesity/diabetes epidemic represents an unprecedented health crisis for California and the nation.

Nutritionists from UC and elsewhere have identified a number of changes over the past 30 years that have contributed to these problems. Daily caloric intake has increased in both children and adults. Inexpensive fast food is readily available. Portion sizes are two to four times the standard sizes recommended by USDA. Schools raise funds by selling high calorie snacks and placing vending machines in the corridors, competing with standard school lunch meals. Aggressive and sophisticated marketing campaigns promote such snacks to children and teens.

At the same time, there are fewer opportunities in daily life for children and adults to burn calories. Schools have replaced or cut back on physical education and sports. Neighborhood parks may be considered unsafe places to play. Some neighborhoods even lack sidewalks. Children watch an average of 3 to 4 hours of television daily. Walking and cycling have been replaced by automobile travel for all but the shortest distances, and the workplace has become increasingly automated.

However, there is scientific evidence that diabetes can be reversed through lifestyle changes, such as moderate exercise and weight loss (see p. 8). The best long-term solution to this problem is to create home, work and school environments that promote healthy food choices and regular physical activity. This can only be achieved by a focused, collaborative effort by all agencies and organizations concerned with the nation's health.

Toward this end, scientists at UC Davis and UC Berkeley are investigating an array of fundamental questions. UC Davis nutritionists are developing information to help individuals deal with obesity more effectively, performing studies on nondiet interventions and clarifying the physiological processes that underlie diabetes.

At the Agricultural Research Service's Western Human Nutrition Research Center at UC Davis, research in the next 5 years will examine the effects of dieting on mineral metabolism and develop approaches to ease negative side effects of dieting such as impaired mental functioning, compromised immunity and lower bone density. Other scientists at the Center hope to identify factors that predispose individuals to excess body weight gain and make them resistant to weight loss.

UC Berkeley researchers are analyzing the degree to which eating patterns developed in early childhood contribute to childhood obesity. Another study focuses on the contribution of teenage pregnancy to body-fat changes and distribution. Researchers are examining the effect of removing highly sweetened beverages from high school vending machines and snack bar shelves. Berkeley nutritionists are also attempting to elucidate the contributions of obesity and high-insulin production to colon cancer.

Agriculture and Natural Resources (ANR) workgroups are extending research findings to the appropriate clienteles (see pp. 7–12). A research study in eight counties is looking at the paradoxical relationship between overweight and hunger in low-income Latino families. Results may ultimately be used to evaluate the effects of state and national food assistance and poverty programs.

Through such avenues of research, as well as outreach programs such as the Center for Weight and Health, UC is setting the standard for a comprehensive approach to this multifaceted problem. With 60% of Americans overweight, obesity and its constellation of associated diseases is our number one nutrition problem. The nation must broaden its approaches to prevention, recognizing that obesity is rooted not only in our automated and sedentary lifestyles, but also in our vast food marketing and distribution systems. Only then can we foster a changed environment that will enable our diverse citizenry to adopt healthier ways of life.

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News departments

Research articles

COVER: The prevalence of diabetes in California has increased 67% since 1980. At south Stockton's Fifth Street Medical Center, two-thirds of Dr. Kwabena Adubofour's clients are Latino, and at significantly higher risk for the disease than non-Latino whites. Adubofour takes the blood pressure of Esther Ferreira, a 55-year-old Stockton resident who was diagnosed with type 2 diabetes 3 years ago. She manages the disease with diet, exercise and regular visits to the doctor. With the guidance of medical professionals such as Adubofour, UC Cooperative Extension advisors have developed diabetes-prevention outreach programs to promote awareness and healthier lifestyles among Latinos and other high-risk populations (p. 8). *Color photo by Phil Schermeister.*

This could be your last issue – time to resubscribe!

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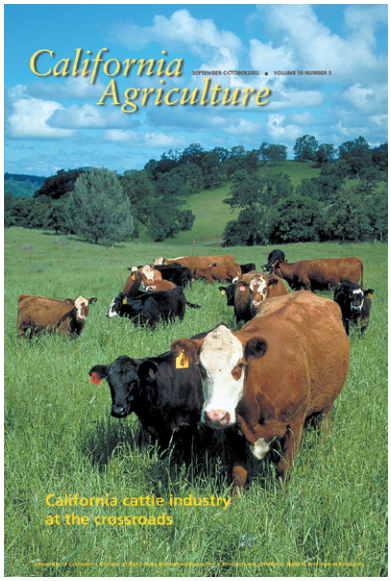
Editor's note:
Due to cutbacks related to the state's budget deficit, *California Agriculture* will publish two issues (rather than three) during the first half of 2003. This issue covers January, February and March 2003. We regret any inconvenience to our subscribers and contributing scientists.

Letters

State's organic dairies competitive

Thanks for publishing the intriguing survey of the comparative production, costs and income of conventional and organic dairy farms (September-October 2002, p. 157–162). This sort of careful, data-rich empirical analysis of organic versus conventional production systems is sorely needed to provide deeper insight into the strengths and weaknesses of alternative production systems. Such insights are key in improving the environmental performance and economic viability of both conventional and organic farms.



In reviewing the findings, I was struck by how well the state's forage-based organic dairies were performing in terms of production and economic returns. Organic dairies received a 27% premium for their milk and netted $1.77 per hundredweight, compared to $0.77 on comparable conventional farms. A careful review of differential costs, however, leads to an even more striking result — most of the higher costs facing the organic producers are largely matters of economic scale and reflect the fact that the organic dairy industry was very modest in 1999. Marketing costs were almost three times higher per hundredweight of milk. Few new, organically acceptable drugs were available. The supply of acceptable replacement heifers was modest and costly. As the scale of the industry grows, these cost differentials and disadvantages facing organic producers will surely diminish. If just marketing costs had been equal in this study, the net return per hundredweight on organic dairies would have been four times the net return on conventional farms.

Other key, higher cost items on organic farms will also gradually fall relative to conventional farms. For example, the 34% premium paid for concentrates will fall over time, probably by close to half. Herd health, land use and environmental advantages are also likely to translate into lower costs for drugs and compliance with environmental and food safety regulations on organic farms. The results of this research suggest that forage-based dairies in California's northern and coastal valleys will compete successfully with conventional dry-lot, confinement operations in the valleys. Given recent growth in the industry, an updated survey would be of great interest in tracking scale-driven changes in production, costs and income.

Chuck Benbrook
Benbrook Consulting Services
Sandpoint, Idaho

The article's author, UC Davis Marketing Economist Leslie Butler, responds:

You are absolutely correct in pointing out that as the relative size of the organic dairy industry increases, many of the cost differentials are likely to diminish. Even since we carried out the survey — which reported 1999 cost of production figures — the number of organic dairy producers in California has increased, as has organic milk production and the supply of organic feed. However, as organic milk production increases, competition with conventional milk production will also increase, and the price differential is likely to diminish. This could come about either as price increases for conventional milk due to diminishing supply, or as price decreases for organic milk due to increases in supply relative to the demand for organic milk. Since the supply of organic feed (relative to conventional feed) and other inputs is dependent, to some extent, on organic milk producers continuing to find it profitable to produce organic milk, the dynamics between organic milk production and the supply and cost of inputs is still quite delicate. The biggest factor on the side of the organic dairy producer in California, as you point out, is the successful substitution of pasture as the main feed.

Traditional forage-based systems in California have been successfully competing with the larger dry-lot operations since the establishment of dairying in California, and the systems have been enhanced over the years by new irrigation technologies and innovative rotational grazing systems. At the same time, recent decreases in the prices of concentrate feeds relative to alfalfa and other hay prices, and the production incentives provided for feed crops by the 2002 Farm Bill, are likely to favor increased concentrate feeding by conventional dairy producers for some time, and are likely to keep them competitive with forage-based organic producers for the next few years.

Given the uncertainties facing the ability of organic

WHAT DO YOU THINK? The editorial staff of *California Agriculture* welcomes your letters, comments and suggestions. Please write to us at calag@ucop.edu or 1111 Franklin St., 6th floor, Oakland, CA 94607. Include your full name and address. Letters may be edited for space and clarity.

milk production to maintain competition with conventional milk production, the fortunes of organic producers rely heavily on the continued and increased demand for organic milk. The current trends, while positive for organic milk demand, bear watching closely. We will be updating our cost of organic milk production survey in California early next year.

Better-tasting beef?

Regarding your articles on the California cattle industry and grass-fed beef (September-October 2002, p. 151, 152), I can offer a new analysis of why beef consumption has dropped. Today I went to Basha's for the last buffalo on sale and it was gone. I told the butcher how good it was and he asked me if I had tried elk. He told me that elk tastes like beef used to taste 20 years ago. There you go. The taste of beef has changed and this may explain why many people have stopped eating it. A lot of people can taste the difference, so they switch to other meats. California should go back to range-fed stock to help the industry. The word will get around that California meat tastes better than other meat. It does not necessarily have to be organic. You should do significant research to ask which feed gives the best consumer taste.

Nick Terebey
Phoenix, Ariz.

Cal Ag a "big eye-opener"

Thank you for the arrival of your magazine! This is one of the most interesting ones that I receive. My concerns and interests revolve around the availability of clean air, water, nutritious food and beautiful landscapes. I am very interested in helping people to better understand how we humans use land. I have some great ideas, and your magazine is a big eye-opener and clarifies many of my ponderings.

Mary Ann Griese
Mountain View

Greetings from the South

I want to compliment you on what a fine job you are doing. As a UC Davis grad, I really miss the state and its agriculture scene. Every time I read your magazine, I get homesick for Northern California.

Richard Mason
Baton Rouge, La.

Science briefs

New grants support battle against olive fruit fly

UC's Division of Agriculture and Natural Resources has funded two new projects to combat the olive fruit fly, a pest that feeds directly on olive fruit and can devastate entire harvests. Since its first appearance in California in 1998, the olive fruit fly (*Bactrocera oleae*) has spread from Los Angeles throughout the state's commercial olive growing areas. It now infests at least 37 counties (see page 28).

Funds totaling $230,000 will support investigations of the fruit fly's seasonal population dynamics and its biological control through the use of natural enemies. The funds are part of $1.8 million in specialty crop funding provided through the state's Buy California Initiative, administered by the California Department of Food and Agriculture.

UC Davis entomologist Frank Zalom and pomologist Louise Ferguson received $50,000 to further investigations to determine when mating and egg laying occur, and how they differ according to tree variety and climate. "If we can predict when the fruit becomes a suitable host for the flies, we can help growers predict when management options should be initiated," Zalom says.

UC Berkeley entomologist Kent Daane and UC Riverside entomologist Marshall Johnson (located at UC Kearney Agricultural Center), and collaborators, have received $180,000 to support the importation and host-range testing of parasitic wasps that attack the olive fruit fly. Daane and Johnson, with scientists from the University of Hawaii and the U.S. Department of Agriculture, will import these natural enemies from sub-Saharan Africa. They will investigate the wasp further to ensure against any nontarget effects, particularly on native species. If the parasitoids do not pose significant threat, the scientists will release and attempt to establish them in olive fruit fly populations within 2 years. Foreign exploration is now under way.

Attracting, retaining and eliciting the efforts of capable employees have always been key to the productivity of California agriculture (see page 13). To help supervisors and managers at all levels who make human-resource management decisions in agriculture, a consortium of land-grant university educators from seven states and Canada recently published *Ag Help Wanted: Guidelines for Managing Agricultural Labor*. UC Berkeley Cooperative Extension specialist Howard Rosenberg was lead author of the 242-page, full-color handbook. *For more information or to place an order, go to www.aghelpwanted.org.*

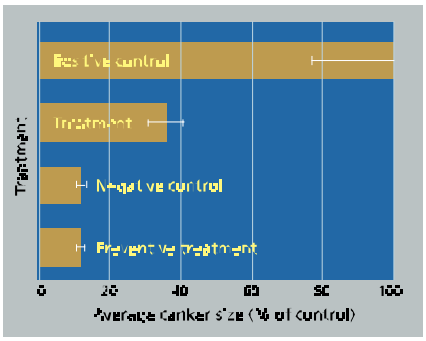
◀ **In this Big Sur canyon sudden oak death has killed many tanoaks, while infected redwoods nearby still look healthy.**

Promising treatment, control options for sudden oak death

AT a December symposium in Monterey, scientists presented research on genetic resistance to sudden oak death, and a promising new chemical treatment. They also confirmed that integrated approaches, such as sanitation and composting of infected plants, are effective control measures.

Caused by a funguslike pathogen called *Phytophthera ramorum,* sudden oak death has been killing native oak trees up and down the state since the mid-1990s. While the disease primarily affects oaks, 13 California native non-oak trees and plants have thus far been confirmed as hosts for *P. ramorum* (see page 18).

Although widespread control strategies are hard to find for forest trees, researchers have been studying epidemics caused by relatives of *P. ramorum,* such as *P. lateralis* on Port Orford cedar and *P. cinnamomi* in a broad range of agricultural and natural systems. Genetic resistance has been widely employed to protect native Port Orford cedars from introduced *P. lateralis* in California, Oregon and Washington.



Effect of phosphonate treatment on canker size in coast live oak. Positive controls were inoculated and untreated; negative controls were wounded (lanced) but not inoculated.

At UC Berkeley, preliminary experiments by UC Berkeley forest scientist Richard Dodd, in collaboration with UC Berkeley forest pathologist Matteo Garbelotto, indicate that not all coast live oak trees are equally affected by *P. ramorum.* In an inoculation experiment performed in spring 2002, six cuttings were taken from approximately 40 adult oak trees throughout the natural range of coast live oak. When exposed to the pathogen, the size of cankers 3 weeks after inoculation was significantly different among individuals and ranged from 0.4 to 3.2 inches (10 to 80 millimeters).

Chemical treatments using nontoxic compounds known as phosphonates are routinely used in orchards to combat *P. cinnamomi* and have been applied successfully in the wild lands of Western Australia and Europe. In multiple controlled experiments by UC Berkeley Cooperative Extension scientists, in collaboration with UC Davis plant pathologist David Rizzo and farm advisors Steven Tjosvold and Pavel Svhira, phosphonates were successfully employed to prevent infection by *P. ramorum* on potted coast live oak trees, 9 to 15 feet tall with trunk diameters of 2 to 4 inches (see figure). When applied to adult trees in the field, the phosphonates also provided significant control and lesions were significantly smaller than in untreated controls.

Despite these promising results, Garbelotto warned, "The method of delivery of the compound, the timing and dosage must be studied before any treatment is evaluated by regulators and formalized for use."

While genetic resistance and chemical controls can provide useful, proactive tools for an integrated pest management approach, the scientists say that sanitation and spread control are still the most powerful methods to slow down sudden oak death. A series of studies done by the Garbelotto research group in collaboration with the California Integrated Waste Management Board showed that plant material infected by *P. ramorum* is noninfectious once properly composted. "If compost is not re-exposed to infection, it should be a viable way to reduce inoculum levels," Garbelotto says.

Researchers and policy-makers agree that sudden oak death presents a serious risk to native California ecosystems and the timber industry, which necessitates a well-financed, focused research effort. Indeed, current studies indicate that there is reason to hope the disease can be brought under control. While alarming numbers of oaks have died, U.S. Forest Service pathologist Susan Frankel noted during a recent lecture at UC Berkeley that sudden oak death is a patchy disease that is "not denuding large areas."

"Species are not being driven to extinction," Frankel said. Rather, sudden oak death is "very poorly named. It's not sudden. It doesn't occur only in oaks, and it doesn't always result in death of the tree."

— *Janet Byron*

Healthier lifestyles key to solving childhood obesity epidemic

With studies revealing that childhood obesity has tripled in the United States since 1980, UC researchers have taken a leading role in developing educational resources and outreach programs to reverse this alarming trend.

"We must change community environments so they are more supportive of healthy lifestyles, or we will not be able to address this problem," says Joanne Ikeda, UC Cooperative Extension (UCCE) nutrition education specialist and co-director of the UC Berkeley Center for Weight and Health.

According to a recent American Medical Association report, nearly 9 million U.S. children ages 6 to 9 are now seriously overweight. "This trend has contributed to troubling increases in the incidence of serious, chronic diseases such as diabetes and other weight-related illnesses in children," says Pat Crawford, UCCE nutrition specialist and Center co-director. "Not surprisingly, this mirrors similar trends in adults" (see pages 3, 8).

Furthermore, obesity rates are rising fastest among low-income, ethnic minorities including African American, Native American and Latino children. The multiethnic Oakland school district, for example, recently took the unusual step of hiring California's first school nurse whose sole assignment is to educate students, parents and teachers about diabetes.

Nearly 9 million U.S. children ages 6 to 9 are now seriously overweight. — *AMA*

To focus on environmental, family-based and clinical strategies, the Center is cohosting the 2003 California Childhood Obesity Conference in San Diego in early January 2003, with the California Department of Health Services. In addition to pursuing important pediatric nutrition research, UC scientists and advisors have offered workshops around the state and developed an array of resources to promote healthier eating habits and lifestyles among children.

Community resource kits. "Children and Weight: What Communities Can Do" is a "how-to" guide for community leaders who want to start a coalition for preventing weight problems in children. The philosophy behind the kit, which was developed by Ikeda and Crawford with the California Fit Women, Infants and Children (WIC) Project, is that the best way to slow or halt excessive weight gain in children is to create environments that provide them with more opportunities to eat well and be physically active.

Lobsang Wangdu

To address childhood weight issues positively, UC Cooperative Extension advisors created the *Nutri-Link* program, which uses computers and hands-on activities to teach youth about healthful eating. Undergraduate research apprentices in the UC Berkeley School of Public Health helped pilot test the program at an Oakland YMCA last spring.

The kit contains the essentials for establishing community coalitions, helping groups set goals, formulating action plans, and staying focused and energized, says Kirstin Siemering, UC Berkeley graduate student and development team member. "Often the hardest part in forming a coalition is getting started, so we focused on the nuts and bolts of organizing the first five meetings, and made the materials as user-friendly as possible." A similar kit targeting health professionals was released in early 2000.

Nutrition and computers. Last June, UCCE Alameda County child/youth program coordinator Jo Ann Johnson rolled out the *Nutri-Link* program, a Web-based after-school program designed to help youth learn about healthful eating and physical activity in order to reduce the risk of chronic diseases. Youth acquire computer and critical-thinking skills via hands-on science activities and game play designed to reach a multicultural audience. "It is easy to teach nutrition, but not as easy to influence behavior nor guarantee access to healthy foods," Johnson says. "*Nutri-Link* reinforces the cornerstones of public health nutrition: moderation, variety and balance."

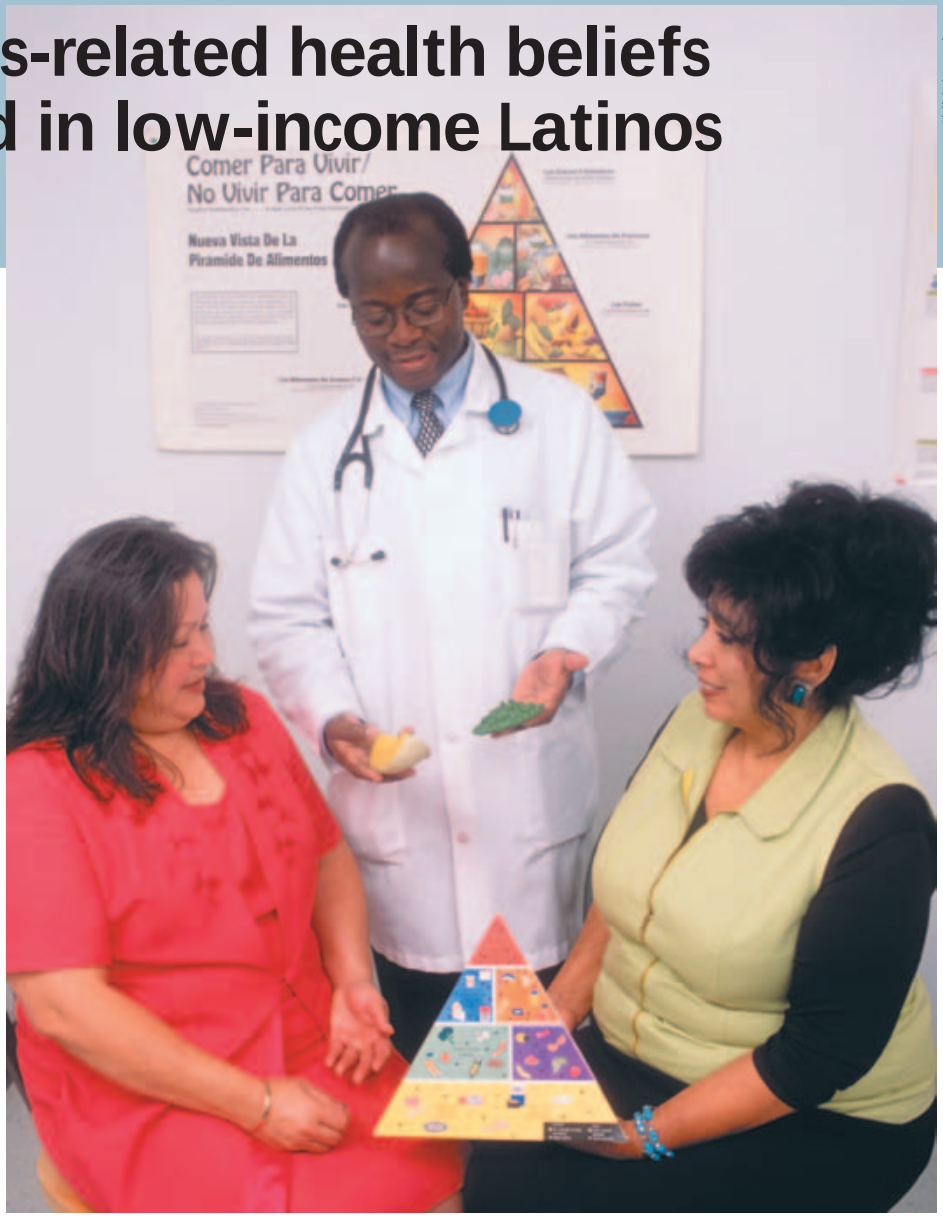
Weight acceptance television show. Ikeda worked closely with producers of "A Walk In Your Shoes," a television show geared to early teenagers, on a half-hour segment on weight discrimination. One goal was to help prevent the psychological trauma that many overweight children experience. The show was first broadcast on The N and Nickelodeon channels last October, accompanied by lesson plans for educators. — *Editors*

For more information, go to:
www.cnr.berkeley.edu/cwh

Diabetes-related health beliefs explored in low-income Latinos

Lucia L. Kaiser
Marciel A. Klenk
Anna C. Martin
Anna Olivares
Amy B. Joy
Hugo Quiñonez-Melgar

We conducted focus group discussions and a survey to explore diabetes-related health beliefs and to assess educational needs among low-income Latino adults, primarily of Mexican descent. We found that many low-income Latinos served through UC Cooperative Extension programs may be at high risk of developing diabetes. At the same time, many of those at risk lack awareness of risk factors for diabetes, have never been screened and do not know where to go for advice. Although some were unsure of the true causal connection, 64% of the focus group participants had heard that susto (stress or strong emotion) might be related to onset of the illness. In addition to increasing awareness of the disease and reducing barriers to care, nutrition educators can help program participants by identifying ways to alleviate the effects of stress and lower the risk of diabetes through a healthy lifestyle.



Phil Schermeister

At the Fifth Street Medical Center in Stockton, UC Cooperative Extension nutrition educator Anna Olivares (right), reviews healthy food choices with Blanca Reyes (left) and Dr. Kwabena Adubofour. Reyes, a native of Siñaloa, Mexico, was diagnosed with gestational diabetes during her last pregnancy and now suffers from type 2 diabetes.

Between 1990 and 1998, California experienced an increase of 67% in the prevalence of diabetes, from 4.9% to 6.9% of the total population (Mokdad et al. 2000). Experts believe this trend, also observed nationwide, is due to the obesity epidemic, as excess body weight is a major risk factor for type 2 diabetes. Since diabetes can damage almost every major organ and shorten the life span by an average of 10 to 15 years, the economic implications of this trend are profound. Currently the estimated cost of diabetes to the nation is over $105 billion annually (Diabetes Research Working Group 1999). More than 1 out of 10 U.S. health dollars in 1999 were spent on diabetes.

Diabetes refers to a class of diseases, characterized by high blood glucose levels. All types of diabetes are probably influenced by genetic, environmental and/or lifestyle factors (Diabetes Research Working Group 1999). Between 5% and 10% of all cases are classified as type 1 diabetes, which usually develops during childhood or adolescence. The onset of type 1 diabetes appears to be linked to an autoimmune process that destroys the insulin-producing beta cells in the pancreas. People with type 1 diabetes must take insulin by injections or pump in order to avoid unconsciousness, coma and death.

Between 90% and 95% of all diabetes cases are type 2, which generally develops later in life. Type 2 diabetes is characterized by increased resistance to insulin in the body and/or a relative deficiency of insulin. Obesity and lack of physical activity increase the chances of developing type 2 diabetes in geneti-

To promote healthier lifestyles among Latinos at-risk of diabetes, UC Cooperative Extension advisors developed the "Take Care of Yourself: Diabetes Awareness and Education" curriculum. In Escalon, Anna Olivares conducted a diabetes-prevention workshop for Spanish-speaking women at the Dent Elementary School's Family Literacy Program. Participants enjoyed "chair dancing" to music from around the world.

cally susceptible people.

A third form of the disease is gestational diabetes, insulin resistance that some women experience during pregnancy. Although gestational diabetes usually disappears after delivery, half of women who have had this form of diabetes will develop type 2 diabetes later in life. Furthermore, impaired glucose tolerance (IGT) is a condition where blood glucose levels are higher than normal but not high enough to be classified as diabetes. Up to half of the people with IGT may develop type 2 diabetes in 2 to 12 years (Bourn 1996). Diabetes is a progressive, chronic disease that cannot be cured. However, careful management through diet, physical activity and usually medication can decrease the risk of complications and improve the quality of life.

Prevalence and prevention

Recently, a multicenter, randomized, controlled trial showed that intensive lifestyle changes can reduce the incidence of type 2 diabetes over a 3-year period by as much as 58% in an ethnically diverse population at high risk (Diabetes Prevention Program Research Group 2002). These lifestyle changes include 30 minutes of moderate physical activity on most days of the week, a weight loss of 7% and a low-fat diet. Sustaining intensive lifestyle changes over the long term may be difficult, but even if the onset of diabetes could be delayed by only a few years, the personal benefits and health care cost savings would be substantial.

In the United States, the prevalence of type 2 diabetes is significantly higher in Latinos, American Indians and African Americans than in non-Latino whites. Mexican Americans are 2.5 times more likely to develop diabetes than non-Latino whites (Haffner 1998). Mexican Americans also tend to have higher fasting blood-glucose levels and suffer more diabetes-related complications than non-Latino whites (Harris et al. 1999; Hosey et al. 1998). These disparities could be due to a more severe form of diabetes, barriers to health care or both. Culturally sensitive interventions have been successful in improving diabetes knowledge, dietary management and blood sugar control in Latinos with diabetes (Brown and Hanis 1995; Vazquez et al. 1998).

To develop effective programs that increase awareness and encourage early screening, more research is needed on health beliefs and barriers to care in minority populations. The purpose of this study was to explore the perceptions, beliefs, attitudes and behaviors related to diabetes and assess the need for education in low-income Latino adults, primarily of Mexican descent.

In the first stage of our study, four focus group discussions were conducted among Latino adults with type 2 diabetes who resided in three California counties: Napa (two groups), San Joaquin (one group) and Stanislaus (one group). This provided a mix of rural and urban populations in Central and Northern California. In the second stage, a short questionnaire, based on themes discussed during the focus groups, was administered to Latino participants in the Expanded Food and Nutrition Education Program (EFNEP) in San Joaquin and Stanislaus counties.

TABLE 1. Characteristics of EFNEP clients participating in diabetes survey (n = 120)

	Mean ± standard deviation or %, n
Age (years)	35.9 ± 10.0 (range: 21–64)
Gender	95% female
Body mass index (kg/m^2)	29.7 ± 6.7
Physical activity:	
Never	15.1%, 18
< Once a week	15.1%, 18
At least once a week	26.1%, 31
Several times a week	22.7%, 27
Daily	21.1%, 25
Household income ($ per month)	1001 ± 677
Household size (no.)	4.3 ± 1.7
Birth country:	
Mexico	78.2%, 93
United States	20.2%, 24
Other Latin American country	1.6%, 2
Proportion of life in the United States (0–1.0) (range: 0.02–1.0)	0.48 ± 0.32
Education:	
No schooling	1.7%, 2
< 6 years	11.7%, 14
≥ 6 years but < 12 years	59.2%, 71
≥ 12 yrs.	27.5%, 33
Ever been screened for diabetes:	
Yes	55.6%, 65
No	44.4%, 52
Family history of diabetes:	
Yes	45.8%, 55
No	40.0%, 48
Not sure	14.2%, 17
Know where to be screened for diabetes:	
Yes	62.5%, 75
No	37.5%, 45
How would you rate your risk of getting diabetes in the next 5 years?	
High	4.2%, 17
Average	20.0%, 24
Low	9.2%, 11
Don't know	56.7%, 68

Most of the EFNEP participants were not expected to have diabetes, since the program is designed to deliver basic nutrition education to the general population. The UC Davis Human Subjects Review Committee exempted the protocol from full review.

Focus group discussions

UC Cooperative Extension (UCCE) staff recruited the participants for the focus groups through agency staff from local health clinics in the three counties. All participants were adults (ranging in age from about 30 to 75 years), self-identified as Mexican American, Latino or Hispanic, and had been diagnosed with diabetes. Subjects were offered refreshments and a $15 gift certificate as an incentive to participate in the discussion.

The questioning guide and protocol were developed based on Krueger's (1994) guidelines. The questions explored the perceived causes of diabetes, context surrounding the diagnosis, the participant's current experience with diabetes, intervening conditions, actions taken as a result of diabetes and consequences of those actions. The first author, who is bilingual and experienced in leading focus groups, moderated all four groups in Spanish. The co-moderators, who handled recruitment and took notes, were bilingual Latinas. Each session lasted about 90 minutes and was audiotaped, translated and transcribed by the co-moderators. A second native speaker (H. Melgar) checked the tapes and transcripts. Two researchers (L. Kaiser and H. Melgar) independently coded, sorted and categorized segments of the transcripts using an approach termed axial coding (Strauss and Corbin 1990). Interobserver ratings agreed in more than 82% of the cases. The remaining cases were re-examined and discussed until consensus was reached.

Participants. Twenty-eight Latinos (23 females, 5 males) participated. Most were born in Mexico (only two were U.S. born). The participants had diabetes for an average of 6.5 years (from 2 months to 26 years). Most were currently married (22 married, three widowed, two single, one divorced). Fifty-seven percent (n = 16) reported that at least one close family member (parent, grandparent, sibling or child) also had diabetes.

Themes. A major theme was the belief that shock, worry, anger, sadness or an emotional event (termed here as *susto*) causes diabetes. Although some were uncertain about a causal relationship, most (64%) had heard that *susto* might be related to the onset of the illness. The specific reasons why people thought diabetes might result from *susto* were not discussed. However, people who believed *susto* might be a factor cited both immediate cause-and-effect examples such as death of a parent or an accident, as well as more prolonged periods of sadness and depression related to coming to the United States. Other factors mentioned less often than *susto* included obesity (21%), fatty food (21%), sugar or soda (21%), an unbalanced diet (11%) and medications (3%). While more than half had at least one family member with diabetes, only three subjects (11%)

Focus group responses: Latinos and diabetes (Napa and Stanislaus county women)

"My mother told me I shouldn't take insulin, it is bad, dilutes the blood."

"Some people are afraid of other people knowing that they have diabetes. I was one of those people but my doctor explained it to me and I understood that it is a disease that we can control."

"I think that I got it (diabetes) because of anger *(coraje)*. Nobody in my family has it. I think it's *coraje* and fright *(susto)* together that do it."

"We Hispanics eat a lot of fat, and we eat very few vegetables. We eat more fat — like *pozole (*a stew with chili, corn and pork) — pure fat, pork skin and from there the diabetes is due to the fat."

"Have less worries. Have a good outlook. Resign ourselves to the fact that God knows what he is doing. Get medical care and abide by the advice that the doctor gives you."

mentioned family traits or genetics as causal. In each of these cases, several close family members had diabetes.

Other health beliefs and attitudes about diabetes were mentioned. Some subjects had heard from family members that insulin dilutes the blood or causes blindness. One woman mentioned that she had been ashamed to let others know she had diabetes. Several people voiced the belief that everyone — especially Mexicans — has diabetes, but in some people the disease just develops faster. Religious beliefs were mentioned but with a realism about internal control over the disease. In other words, while becoming ill may be perceived as part of God's design, the individual should not abandon self-care.

EFNEP survey

Based on the focus group themes, a set of questions was developed, translated into Spanish, cross-checked by a diabetes educator in Napa County, and tested in a discussion group with the target audience. Starting in early 1999, the UCCE nutrition educators in San Joaquin and Stanislaus counties contacted schools and family community centers to schedule their usual EFNEP classes. The first eight classes that targeted Latino adults were selected for the survey. (Classes scheduled at drug rehabilitation programs were not included in the sample.) Upon enrollment in EFNEP, 132 participants completed the standard EFNEP family record form, food behavior checklist and our supplemental set of 40 diabetes-related questions. The survey was self-administered and mainly included agree / disagree / not sure response categories.

To get a measure of acculturation, data was collected on country of birth and years of residence in the United States. A portable electronic scale and stadiometer were used to weigh and measure the participants. Nine percent of the participants (n = 12), who reported having diabetes, were excluded from the data analysis. Descriptive statistics were prepared using SAS, Version 8.0 (SAS Institute, Cary, N.C., 1999–2000). The relationship between health beliefs and acculturation was examined using Spearman's correlation, with a *P* value of less than 0.05 considered significant.

Participants. Although the overall profile (ethnicity, overweight, positive family history, older age, sedentary lifestyle) suggests that many participants in EFNEP classes may have significant risk factors for type 2 diabetes (table 1), 44% reported never having been screened. Thirty-seven percent did not know where to be screened for diabetes, and only 14% considered themselves to be at high risk.

Health beliefs. Among this population of Latinos, emotional stressors were widely believed to play a role in the onset of diabetes (44% agreed) (table 2). Many were uncertain (71%) or agreed (17%) that insulin injections might be harmful. Only 38% believed that diabetes cannot be cured. However, many did not feel that diabetes is inevitable (48%) and claimed they would not be afraid to be screened (60%). The proportion of one's life spent in the United States was positively correlated with many of the items, suggesting that more acculturated Latinos have greater knowledge about diabetes.

Nutrition education implications

Our results are consistent with other studies conducted elsewhere among Latinos. In South Texas, Mexican Americans with type 2 diabetes commonly cited provoking events, in addition to biomedical factors, as a cause of their illness (Hunt et al. 1998). The belief that fright, anger and other strong emotions might cause diabetes appears to be more widely held among Mexicans and Guatemalans than among Puerto Ricans and more-acculturated Latino subgroups (Weller et al. 1999). Traditional folk beliefs relate *susto* (stress or strong emotion) to the onset of depression and malaise in general, not just diabetes (Kittler and Sucher 1995). The association of imbalance (emotional or physical) with illness and disease may actually have its origins in the ancient pre-Columbian medical-food system (Grivetti 1992). Although stress is not believed to be causally related to diabetes, it may act as a trigger in people who have undiagnosed diabetes and result in a worsening of the condition so that the illness becomes apparent.

TABLE 2. Health beliefs and attitudes (Spearman correlation coefficient, *P* value) related to diabetes awareness and prevention, and correlation with proportion of life spent in the United States (n = 120)

	Mean ± standard deviation or %, n
Knowledge of diabetes symptoms (score: 0–7)* (r = 0.28, P < 0.002)	4.9 ± 2.1
Taking insulin injections can cause blindness or thin the blood† (r = 0.29, P < 0.002)	
Agree	17.5%, 21
Not sure	71.7%, 86
Disagree	10.8%, 13
Shock, anger or worries are the most important causes of diabetes (r = 0.18, P < 0.05)	
Agree	44.2%, 53
Not sure	36.7%, 44
Disagree	19.2%, 23
I am afraid to get screened for diabetes, because I wouldn't want others to know I have this disease (NS‡)	
Agree	19.2%, 23
Not sure	20.0%, 24
Disagree	60.8%, 73
There is little one can do to avoid getting diabetes (r = 0.33, P < 0.0002)	
Agree	15.8%, 19
Not sure	36.7%, 44
Disagree	47.5%, 57
There is a cure for diabetes (r = 0.19, P < 0.04)	
Agree	27.5%, 33
Not sure	34.2%, 41
Disagree	38.3%, 46
Having diabetes would mean that you can no longer work or carry heavy things (r = 0.29, P < 0.001)	
Agree	4.2%, 5
Not sure	36.7%, 44
Disagree	59.2%, 72
Following a diabetic diet would mean that you cannot eat the foods you like (r = 0.18, P < 0.05)	
Agree	40.8%, 49
Not sure	23.3%, 28
Disagree	35.8%, 43
Getting regular exercise can lower my risk of getting diabetes (NS)	
Agree	61.3%, 73
Not sure	26.1%, 31
Disagree	12.6%, 15
Eating more fiber can lower my risk of getting diabetes (NS)	
Agree	65.6%, 78
Not sure	26.1%, 31
Disagree	8.4%, 10

* Score based on number of correctly identified diabetes symptoms (thirst, weight changes, headache, dizziness, loss of vision, frequent urination, feeling tired).

† For all knowledge questions (except knowledge of diabetes symptoms), response categories were coded: 1 = agree, 2 = not sure, 3 = disagree.

‡ Not significant.

In Connecticut, greater diabetes knowledge was also positively correlated with longer residence in the United States. In Illinois, health providers have similarly encountered negative beliefs among Latinos about insulin (Lipton et al. 1998). These providers have expressed the concern that fear of insulin may pose an even greater barrier to care than lack of financial resources.

Since 95% of the participants in our survey were female, more research about health beliefs in Latino males is needed. However, since Latino women tend to participate more often in community nutrition education classes, this research has important implications for nutrition educators, especially those working in Cooperative Extension programs. Many low-income Latinos served through Cooperative Extension may have significant risk factors for diabetes, yet lack awareness of risks, have never been screened and do not know where to go for advice. Nine percent of the subjects enrolled in the EFNEP classes that we surveyed reported *actually having diabetes*. Preliminary unpublished results from surveys conducted in New York, Pennsylvania, Arkansas, Maryland and Washington also report a diabetes prevalence of 9% for their EFNEP participants (n = 519) and 18% for participants in the Food Stamp Nutrition Education Program (n = 321)(unpublished data, Butkis 2002). While diabetes education is a nontraditional area for extension educators, a recent e-mail survey of food and nutrition extension contacts in 38 states found that 90% are already involved in some level of diabetes programming (unpublished data, Archuleta 2002).

The Health Beliefs Model is a theoretical framework that describes how to motivate people to take a specific action or change a behavior to improve their health (Rosenstock 1990). Using the Health Beliefs Model and findings from this study, EFNEP educators can develop an effective, culturally relevant approach for Latinos to:

- Increase awareness of risk factors (perceived risk).
- Inform people about the consequences of diabetes (perceived severity).
- Reduce barriers to seeking care and adopting a healthy lifestyle (perceived barriers).
- Increase awareness that physical activity, a low-fat diet and weight management may be able to prevent type 2 diabetes (perceived benefits).

Because stress is perceived to be related to health status in this population, culturally sensitive Cooperative Extension programs can help Latino participants by increasing diabetes awareness, reducing barriers to care and identifying ways to alleviate stress and lower risk of diabetes through a healthy lifestyle. "Take Care of Yourself: Diabetes Awareness and Prevention," a new curriculum based on this research, was designed to achieve those objectives in low-income Latino populations, and is now being implemented in San Joaquin and Stanislaus counties and around California.

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Suzanne Paisley

Many low-income Latinos served by UC Cooperative Extension may have significant risk factors for diabetes, yet lack awareness and have not been screened. Early intervention, such as teaching young people healthier eating habits, is critical for preventing and managing type 2 diabetes.

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Mandatory mediation changes rules for negotiating farm labor contracts

Philip Martin
Bert Mason

In September 2002, Governor Gray Davis signed the first major amendments to the 1975 Agricultural Labor Relations Act in 27 years. Under these amendments, if a farm employer and certified union are unable to negotiate a first collective bargaining agreement within 6 months, a mediator can impose an agreement. The number of contracts in California agriculture has declined precipitously since the mid-1980s, and we are skeptical that mandatory mediation will sharply increase the number of workers employed on farms under collective bargaining agreements.

In August 2002, labor unions rallied for the first reforms to the state's Agricultural Labor Relations Act since 1975. To encourage Governor Davis to sign the law, the United Farmworkers retraced the route of a historic 1966 march led by Cesar Chavez along Highway 99 from Merced to Sacramento.

IN fall 2002, Governor Gray Davis signed the first major amendments to the 1975 Agricultural Labor Relations Act (ALRA) in 27 years. Under these amendments (SB 1156 and AB 2596), if a farm employer and certified union are unable to negotiate a first collective bargaining agreement within 6 months, a mediator can impose one. These new "mandatory mediation" procedures will apply to farm employers with 25 or more workers, and are limited to a maximum of 75 labor disputes between 2003 and 2007.

The purpose of the 1975 ALRA was to end a decade of strife and "ensure peace in the agricultural fields by guaranteeing justice for all agricultural workers and stability in labor relations" (ALRA section 1140). The ALRA includes three major elements: organizing and bargaining rights for farmworkers; unfair labor practices when employers and unions interfere with these worker rights; and a state agency, the Agricultural Labor Relations Board (ALRB), to supervise elections for farmworkers to decide if they want to be represented by unions and to remedy unfair labor practices.

California in the mid-1970s had about 35,000 farm employers, and it initially appeared that many of the 600,000 to 800,000 workers employed on farms sometime during a typical year wanted to be represented by unions. Between 1975 and 1984 there were about 950 elections on California farms, 775 of which resulted in the ALRB's certification of a union as the bargaining representative for workers on a farm or for no union representative. During this first decade, unions were certified 88% of the time and no union was certified in 12% of the cases. Since then there have been 225 elections, and unions were certified as winners on less than 50% of farms where elections were held (fig. 1).

There are many reasons for the declining ability of farmworker unions to request and win elections and be certified as the bargaining representatives for farmworkers, including the inability of farmworker unions to negotiate first agreements with farms where they were certified to represent workers (Martin 2001). The number of collective bargaining agreements in California agriculture has never exceeded 300, and in 2002 there were about 225, with 80% of the current contracts covering three to four workers each under Christian Labor Association contracts with dairy and poultry farms. The United Farmworkers (UFW), Teamsters and other unions representing field workers currently have fewer than 30 contracts covering less than 25,000 workers.

Unions push for change

Unions such as the UFW charge that farm employers have avoided reaching first or subsequent contracts by refusing to bargain toward agreement. The UFW led the effort to amend the ALRA for intervention that would ensure contracts on farms where workers have voted for union representation. The union's original goal was binding arbitration, sometimes called interest arbitration to distinguish it from grievance arbitration (the settlement of issues that arise under a contract).

Under binding or interest arbitration, a union and employer that cannot agree on a contract typically go through a three-step procedure. First is mediation, when a neutral third party listens to each party separately and makes suggestions to narrow differences and

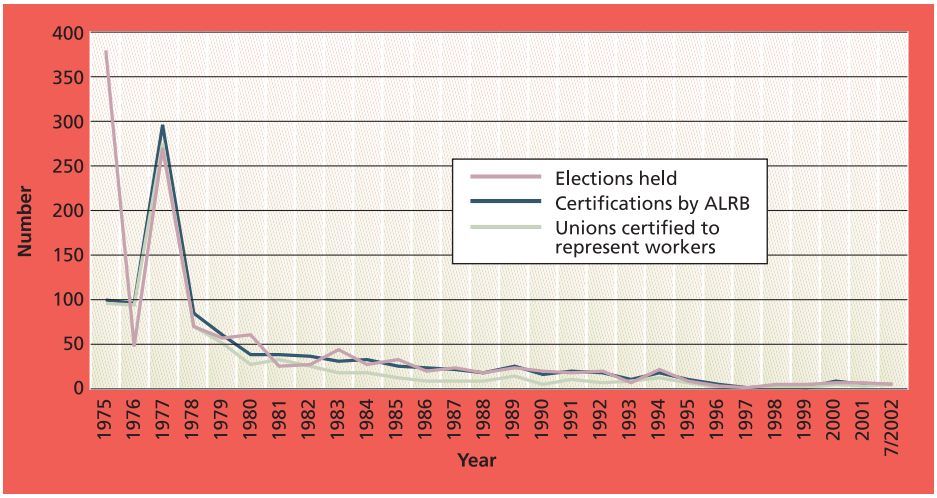

Fig. 1. Union elections and certifications by ALRB, 1975–2002. Data is for calendar years, except in 2002. Source: ALRB, http://www.alrb.ca.gov.

allow them to reach a voluntary settlement. Second is fact finding, when a neutral party listens to both sides and proposes a nonbinding settlement. Third is binding arbitration, when a neutral party proposes either any settlement deemed best or when the arbitrator is required to recommend one of the party's final offers at the bargaining table. Binding arbitration is normally restricted to public employees such as police and firefighters who cannot strike lawfully.

In justifying the need for binding arbitration in California agriculture, the UFW's first bill, SB 1736, stated that:

> "Extensive use of undocumented workers and farm labor contractors results in workplace injustice, and has greatly weakened the bargaining power of California farmworkers since the passage of the Agricultural Labor Relations Act . . . Binding arbitration will promote comprehensive collective bargaining agreements, and further peace and stability in labor relations in California's most vital industry."

The California Senate approved SB 1736 on a 21-13 vote in May 2002, and the Assembly approved it on a 49-22 vote in August 2002. To encourage Governor Davis to sign SB 1736, the UFW in August 2002 retraced the route of UFW marches in 1966 and 1994 in a "March for the Governor's Signature" from Merced to Sacramento along Highway 99.

Farmers bitterly opposed binding arbitration because they felt it could lead to contracts "imposed" on them. With Governor Davis expected to veto SB 1736 because of grower opposition, the UFW persuaded the Legislature to approve a last-minute compromise called mandatory mediation. Under the bills signed into law, which go into effect Jan. 1, 2003, farmworker unions and farm employers bargain for 180 days for a first contract. If they cannot reach agreement, a mediator tries to help the parties resolve their differences for another 30 days. If mediation fails, the mediator would, within 21 days, recommend the terms of a collective bargaining agreement to the ALRB and provide reasons for wage recommendations that are based on the record.

The ALRB then reviews the mediator's report (the proposed collective bargaining agreement), and either issues a final order that makes the contract effective, or begins a review of one or more portions of the contract while allowing other portions to go into effect. Unions or employers objecting to the mediator's report must specify the "particular provisions" and the "specific grounds" for having the ALRB review them. The ALRB may review objections to the mediator's report only if the provisions in question do not relate to wages and working conditions, or if they are "based on clearly erroneous findings of material fact." Either the union or the employer may ask a court of appeal to review the proposed contract within 30 days, and ask a court to enforce the collective bargaining agreement within 60 days.

How many farm employers could be affected by mandatory mediation? Mandatory mediation is an experiment. A party — unions or employers — may request mediation for up to 75 cases between 2003 and 2007; there is some dispute as to exactly who a "party" is. Furthermore, mediation may be requested only on farms with 25 or more agricultural employees during any calendar week in the previous year. Unemployment insurance data suggests that 15% to 20% of farm employers and 75% to 85% of farmworkers could be affected by mandatory mediation. The unemployment insurance data is reported for employers with 20 or more workers, of which there were 3,770 during the third quarter of 2001 — normally the period of peak farm employment. These 20-or-more agricultural employers comprised 17% of all agricultural employers, but they accounted for 83% of workers employed in the third quarter (table 1).

However, smaller farm employers and more workers could also be covered by mandatory mediation. If a farm hires five workers directly and has a farm labor contractor bring a crew of 20 to a farm for 1 week, it becomes eligible for mandatory mediation, since farm labor contractors cannot be employers under the ALRA.

Jack Kelly Clark

California has an average of 450,000 agricultural employees working for 23,000 farm employers. The percentage of farmworkers represented by unions has declined significantly since the 1970s.

TABLE 1. California agricultural employers and employees by size of firm (NAICS*), 3rd quarter, 2001

	Total	Less than 20	20–99	100–999	1,000+	20 or more	(%)
Employers†							
California (all)	1,075,523	941,566	110,687	22,359	911	133,957	(12)
Agriculture	22,626	18,856	2,875	870	25	3,770	(17)
Crop production‡	14,221	12,090	1,744	265	10	2,131	(15)
Ag support activities§	3,934	2,675	769	475	15	1,259	(32)
Employees							
California (all)	14,997,165	3,284,794	4,587,853	4,958,800	2,165,718	11,712,371	(78)
Agriculture	451,039	78,755	119,385	212,091	40,808	372,284	(83)
Crop production	223,306	48,367	70,909	40,251	18,714	129,874	(58)
Ag support activities	193,173	11,947	35,777	123,355	22,094	181,226	(94)

Source: EDD 2002.

* NAICS = North American Industrial Classification System.

† Employers are reporting units.

‡ Crop production and agricultural support activities are subsets of agriculture; livestock is not included.

§ Includes firms such as farm labor contractors, which gather workers and bring them to farms, as well as other support services.

ALRB and make whole: 1975–2002

Farmworkers were excluded from the National Labor Relations Act of 1935, which granted union organizing and collective bargaining rights to most private-sector nonfarmworkers. The ALRA, enacted 40 years later to cover excluded farmworkers in California, included several features to accommodate unique agricultural circumstances, including quick elections, a "make-whole" remedy for bad-faith bargaining and more extensive rights for unions vis-á-vis their members.

The make-whole provision was intended to encourage employers to bargain in good faith by transferring any monetary savings to affected workers, thereby depriving the employer of economic benefits derived from violating their obligation to bargain with the certified union and speeding up bargaining for contracts.

Rose Bird, Secretary of Food and Agriculture in 1975 and a major author of the ALRA, testified that, in light of the discussion in Congress to give the National Labor Relations Board authority to issue make-whole remedies, "since we were starting anew here in California, that we would take that progressive step" and include a make-whole remedy in the ALRA. The ALRB has authority to order employers who fail to bargain in good faith to "take affirmative action including . . . making employees whole, when the Board deems such relief appropriate, for the loss of pay resulting from the employer's refusal to bargain" (ALRA Section 1160.3).

According to its proponents, without a make-whole remedy employers could violate their obligation to bargain in good faith, and the only remedy would be an ALRB order for the employer to do so. Make whole transfers any economic savings from the employer to workers who lost wages and benefits as a results of the employer's violation of the ALRA. But there is still the risk that during the time it takes for the ALRB to order this remedy, the union would lose support due to high turnover and wind up with reduced economic leverage (Martin and Egan 1989).

The make-whole remedy did not work as expected. The UFW asserted that the union won elections and was certified to represent workers on 428 farms. However, it negotiated contracts at only 185 farms, a 43% certification-to-contract rate between 1975 and 2001. The ALRB agreed with the UFW in 2002 that procedures for determining whether make whole is owed, the amount and subsequent distribution of funds to workers usually took years, so that "a remedy designed to act as a goad to bargaining often produces years of litigation" (ALRB 2002).

Slow pace to agreement

Negotiating collective bargaining agreements in California agriculture has often been slow, for several reasons. In an industry with little collective bargaining experience, there are often wide gaps between union demands and employer offers. For example, in 1979 the UFW demanded increases in wages and benefits from vegetable growers that, according to the growers, would have raised labor costs by more than 100% over 3 years. The employers countered with offers of wage increases of 20% to 25%, declared that bargaining was at an impasse, and made unilateral wage changes. The UFW charged these vegetable producers with bad-faith bargaining, and the ALRB agreed in *Admiral Packing* 7 ALRB 43 (1981). However, the Court of Appeals disagreed, concluding that the employers were engaged in lawful hard bargaining, citing the gap between the UFW's demands and the growers' offer to explain why no agreement was likely to be reached (*Maggio et al. v. ALRB*, 154 Cal. App. 3d 40 [1984]).

Even when it is clear that the employer has engaged in bad-faith bargaining, the ALRB must decide what wages and benefits would have been agreed to if the employer had bargained lawfully; calculate the difference between "good faith" and actual wages and benefits; collect funds from the employer; and then distribute them to workers, a process that can take several years.

Under the ALRA's make-whole remedy, the Agricultural Labor Relations Board can order employers to pay wages and benefits to workers if they fail to bargain in good faith with unions. While the ALRB has ordered $34 million in make-whole payments for bad-faith bargaining, only $4.5 million has been distributed to workers.

Furthermore, these calculations are complicated by several factors. First, there can be delays in determining how much an employer owes because of a 1987 Court of Appeals ruling. After the ALRB determines there was bad-faith bargaining, the ruling allows employers to present evidence that even with good-faith bargaining there would not have been an agreement negotiated with higher wages, and thus no make whole is owed (*Dal Porto and Sons v. ALRB*, 191 Cal. App. 3d 1195 [1987]).

Second, no reliable data is available on the wages and benefits of union and nonunion workers in California agriculture. The ALRB often uses a "comparable contract" to determine the amount of make-whole remedies. But the employer often counters that the contract is not comparable because it covers a different commodity mix, is in a different region or covers a different size farm, which produces litigation and delays.

Finally, after the employer exhausts appeals to the courts, the ALRB collects make-whole monies and distributes them to workers. However, in a farm labor force with 10% annual turnover, and that is more than 50% not authorized to work in the United States, it is easy to see why make whole can seem like a hollow remedy. Since 1975, the ALRB has ordered employers to pay $34 million in make whole, but workers received only $4.5 million or 13% of the amount found owing (ALRB 2002). Many of the growers ordered to pay make whole went out of business. Others settled for a fraction of the original remedy, which was accepted because the ALRB knew that more litigation would make it even harder to locate workers owed money. For example, Abatti Farms, whose $1.6 million make-whole payment was 35% of the entire make-whole monies paid in the past 27 years, was originally assessed $19 million (ALRB 2002).

Arbitration and mediation

Despite a steady erosion of contracts and membership, the UFW has been reluctant to lobby for amendments to the ALRA, fearing that this could open the door to pro-grower amendments as well. However, the UFW pushed for binding arbitration in 2002, asserting that it "would replace [make whole] litigation with mediation and arbitration" and contracts. The Western Growers Association, representing fruit and vegetable growers, countered that binding arbitration was "anti-business. We think it could be unconstitutional and we think it's absolutely unnecessary and it will kill California's number one industry" (Rural Migration News, October 2002).

There is little difference to unions and employers between binding arbitration and mandatory mediation: both procedures result in a third party imposing a collective bargaining agreement if there is no agreement at the bargaining table. But will the new mandatory mediation law improve the certification-to-contract ratio in California agriculture? We see three issues that could make mediation another promise unfulfilled in the 3-decade effort to resolve agricultural labor issues via collective bargaining.

Unrealistic demands. With the prospect of mandatory mediation, bargaining may become more unrealistic as unions push for very high wages in negotiations and during mediation, while employers counter that meeting union demands would put them out of business. Instead of negotiating behind closed doors to narrow differences and reach agreement, hard positions in private negotiations could become public debates in mediation hearings marked by rallies and demonstrations.

Lack of data. The mediator could be handicapped by the same lack of data that has impeded quick resolution of make-whole compliance hearings. What data will the mediator use to "establish the terms of a collective bargaining agreement?" Should the mediator rely on the available data for farmworker wages in the region, or on comparable contracts? What weight should be given to assertions that an employer cannot pay more than is being offered and stay in business? The mandatory mediation law includes no

guidance for the mediator, nor does it provide any direction to the ALRB to develop regulations to implement these changes. Mediators may also have credibility problems, since they will first try to mediate farm labor disputes, and then recommend the terms of a collective bargaining agreement.

Contentious elections. There could be more lags between elections and certifications, as election campaigns become more contentious because the parties know that, even if they do not agree on a contract, one can be imposed on them. Employers seeking to delay bargaining would still be allowed to file numerous objections to the election — including time-consuming technical refusals to bargain — that the ALRB and courts must resolve before certifying the union and starting the mandatory mediation clock.

The new mandatory mediation law changes the rules for collective bargaining, allowing a mediator to impose an agreement if collective bargaining does not lead to a contract. Unions hope the law will usher in a new era for farm labor.

Future of bargaining

Since the ALRA was passed in 1975, collective bargaining has not become widespread in California agriculture. There are currently fewer than 250 contracts between unions and the state's approximately 25,000 farm employers (less than 1%). On about 250 farms, workers voted for union representation but have not obtained a contract (another 1%). The goal of mandatory mediation is to secure contracts for certified unions within a relatively short period of time.

The purpose of collective bargaining is to allow the parties closest to the workplace — employers and unions — to establish fair wages and benefits in private negotiations, with both sides using the economic leverage under government-set rules. A cardinal principle of collective bargaining has been that the government does not determine the content of the agreements negotiated, only the procedures under which they are negotiated — like referees who ensure that the game is played by the rules but do not follow the score. The make-whole remedy for bad-faith bargaining required the ALRB to impinge on this hands-off-the-content-of-bargaining rule, and mandatory mediation represents another effort, like make whole, to experiment with a unique remedy to facilitate collective bargaining in agriculture.

The golden age for farmworkers and farmworker unions was 1965 to 1980, when there were no *braceros* and few unauthorized foreign workers in the fields. Cesar Chavez had won widespread support for grape and other boycotts, and competition between the UFW and Teamsters unions convinced many growers that their farmworkers would be represented by unions. The enactment of the ALRA in 1975 was expected to usher in a new era for farm labor in which wages were determined largely by collective bargaining. The reasons cited for the decline of collective bargaining in the 1990s include the rising number of unauthorized workers, many of whom found jobs with the help of labor contractors, and changes within the UFW and at the ALRB that impeded organizing and bargaining. A quarter-century after the ALRA was enacted with high hopes, unions now hope that mandatory mediation will launch the new era for farm labor.

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Non-oak native plants are main hosts for sudden oak death pathogen in California

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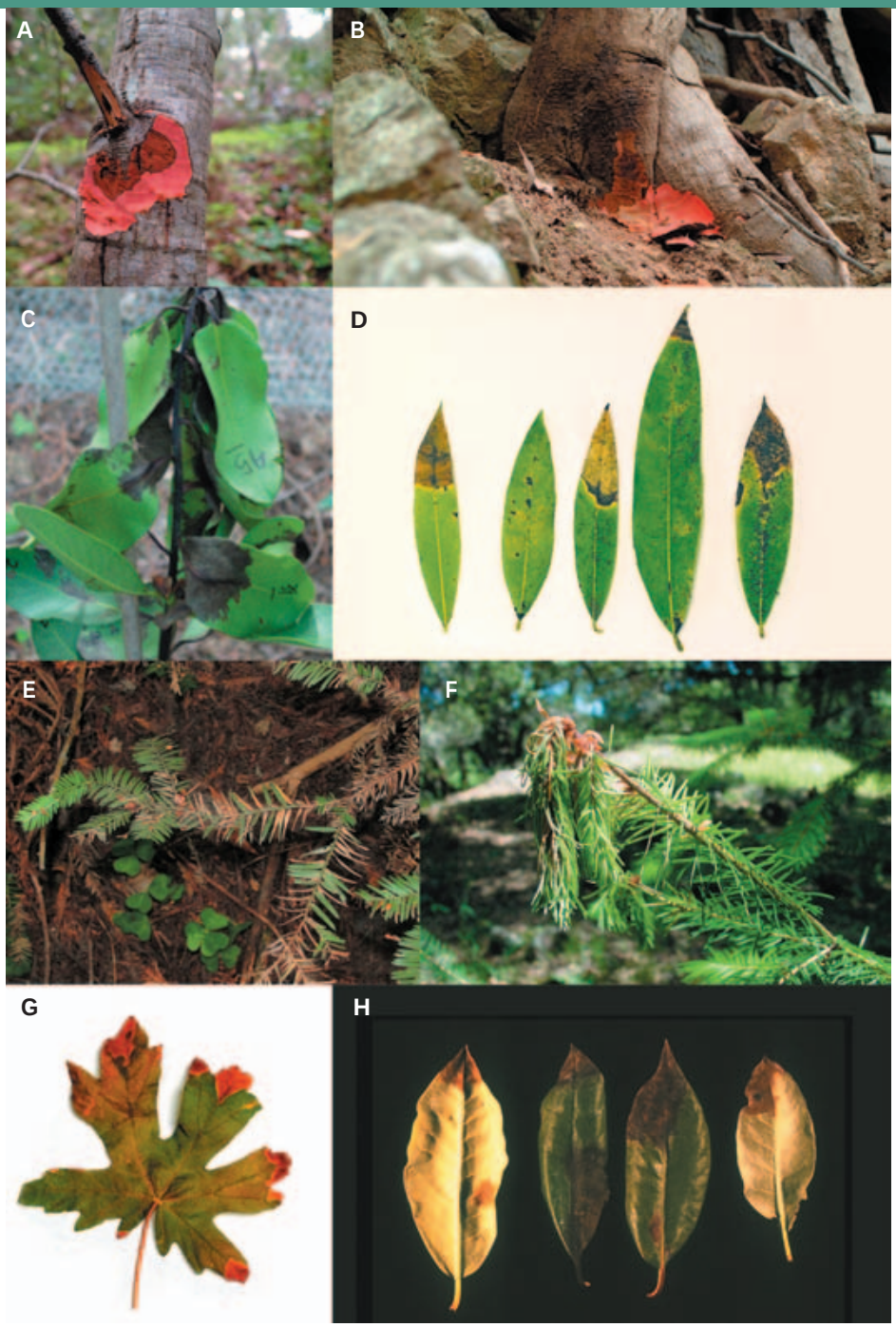
The finding of* Phytophthora ramorum *— the pathogen that causes sudden oak death in four California native trees — on rhododendron in Europe led us to hypothesize that its host range in California's natural forests was much greater than previously suspected. In addition to the affected oak species, we have now identified an additional 13 species from 10 plant families that act as hosts for* P. ramorum *in California. Our data indicates that nearly all of the state's main tree species in mixed-evergreen and redwood-tanoak forests — including the coniferous timber species coast redwood and Douglas fir — may be hosts for* P. ramorum. *The broad host range of* P. ramorum, *the variability of symptoms among different hosts and the ability of the pathogen to disperse by air suggests that it may have the potential to cause long-term, landscape-level changes in California forests.



Symptoms of infection by *Phytophthora ramorum* on various hosts in California forests include: (A) tanoak with phloem canker on main trunk, (B) stem canker on tanoak stops at the soil line, (C) madrone with foliar and stem lesions, (D) bay laurel/Oregon myrtle with leaf-tip necrosis, (E) coast redwood with needle necrosis on understory sapling, (F) Douglas fir with tip wilting due to branch cankers, (G) big leaf maple with marginal leaf scorch, and (H) rhododendron showing foliar lesions.

Known as "sudden oak death" in the popular press, *Phytophthora ramorum* (Phylum Oomycota) is a recently described plant pathogen that causes a deadly canker disease of tanoak, coast live oak, California black oak and Shreve's oak in California and Oregon (Rizzo et al. 2002b; Goheen et al. 2002). This disease has reached epidemic proportions in oak

TABLE 1. Known hosts of *Phytophthora ramorum* in California, plant part infected and original detection method

Host: common name, species	Plant part infected	Detection method
Bay laurel/Oregon myrtle, *Umbellularia californica* (Lauraceae)	Leaves	PCR
Big leaf maple, *Acer macrophyllum* (Aceraceae)	Leaves	PCR
California black oak, *Quercus kellogii* (Fagaceae)	Main stem	Culture
California buckeye, *Aesculus californica* (Hippocastanaceae)	Branches, leaves	PCR
Coast live oak, *Quercus agrifolia* (Fagaceae)	Main stem	Culture
Coast redwood, *Sequoia sempervirens* (Taxodiaceae)	Branches, leaves	PCR
Coffeeberry, *Rhamnus californica* (Rhamnaceae)	Branches, leaves	PCR
Douglas fir, *Pseudotsuga menziesii* (Pinaceae)	Branches, leaves	Culture
Evergreen huckleberry, *Vaccinium ovatum* (Ericaceae)	Main stem, branches, leaves	Culture
Honeysuckle, *Lonicera hispidula* (Caprifoliaceae)	Leaves	PCR
Madrone, *Arbutus menziesii* (Ericaceae)	Branches, leaves	PCR
Manzanita, *Arctostaphylos manzanita* (Ericaceae)	Branches, leaves	PCR
Ornamental rhododendron, *Rhododendron* sp.1 (Ericaceae)	Branches, leaves	Culture
Rhododendron, *Rhododendron macrophyllum* (Ericaceae)	Branches, leaves	PCR
Shreve's oak, *Quercus parvula* var. *shrevei* (Fagaceae)	Main stem	Culture
Tanoak, *Lithocarpus densiflorus* (Fagaceae)	Main stem, branches, leaves	Culture
Toyon, *Heteromeles arbutifolia* (Rosaceeae)	Branches, leaves	PCR

forests along approximately 185 miles (300 kilometers) of the Central Coast of California during the past 7 years (Rizzo et al. 2002b; Garbelotto et al. 2001).

Initial work on the disease in California concentrated on oaks and oak mortality. However, in December 2000, we learned of a possible connection with an undescribed species of *Phytophthora* causing a stem and leaf blight on ornamental rhododendron and viburnium plants in Germany and the Netherlands (Rizzo et al. 2002b; Werres et al. 2001). A comparison of morphological characters and DNA sequences confirmed that the California and European pathogens were the same species of *Phytophthora* (Rizzo et al. 2002b). The European *Phytophthora* was eventually described as *P. ramorum* (Werres et al. 2001) and this name was applied to the California oak pathogen (Rizzo et al. 2002b).

The finding of *P. ramorum* on rhododendron in Europe led us to hypothesize that its host range in California's natural forests was much greater than previously suspected. Using the symptoms described for three affected oak species (*Quercus* spp. [*Q. kellogii, Q. agrifolia, Q. parvula* var. *shrevei*]), tanoak *(Lithocarpus densiflora)* and rhododendron as a guide, we examined and sampled leaves and stems of tree and shrub species on numerous sites with oak mortality in California. In addition to the original four host species in the oak family (Fagaceae), we have now identified an additional 13 species from 10 plant families as hosts for *P. ramorum* throughout its range in California forests (table 1). Our data indicates that nearly all of the main tree species, including the coniferous timber species coast redwood *(Sequoia sempervirens)* and Douglas fir *(Pseudotsuga menziesii)*, in mixed-evergreen and redwood-tanoak forest types may be hosts for *P. ramorum*. Oaks in the subgenus *Quercus* (such as the white oaks) still appear to be unaffected by *P. ramorum*. Understory shrubs — such as manzanita *(Arctostaphylos manzanita)*, toyon *(Heteromeles arbutifolia)*, coffeeberry *(Rhamnus californica)* and honeysuckle *(Lonicera hispidula)* — are also hosts for *P. ramorum*.

DNA aids in new-host discovery

Field diagnosis of *P. ramorum* was initially attempted via direct isolation from symptomatic plant tissue. *Phytophthora* species, however, are often difficult to culture from plants, which may lead to false-negative isolations and misdiagnoses. Our DNA-based diagnosis consisted of a process including: 1) freeze-drying of samples, 2) grinding of infected plant tissue and DNA extraction, and 3) amplification of *P. ramorum* DNA using the polymerase chain reaction (PCR). Once amplified, the DNA can be analyzed in a variety of ways to confirm that it belongs to the target species. Four specific PCR primers were developed based on sequences of the internal transcribed spacer (ITS) of nuclear ribosomal DNA unique to *P. ramorum* (Garbelotto et al. 2002). Two new protocols were also developed to eliminate cross-reactivity with various other species.

Overall, we found direct PCR amplification from symptomatic plant tissue to be more sensitive and reliable than culturing for initial detection of *P. ramorum*. Of the 13 non-oak host species we have identified in California, 10 were first detected this method (table 1). Although cultures of *P. ramorum* have been obtained from all but one host species, the time period necessary to identify its expanded host range was considerably shortened by the use of species-specific molecular primers.

Pathogen evaluated in hosts

Isolation of *P. ramorum* from symptomatic plants was the first step in determining the pathogenic role played by this microbe on new hosts. However, association between symptoms and the presence of *P. ramorum* does not necessarily imply that this microbe plays a primary causal role. Rather, *P. ramorum* may simply be an opportunistic colonizer of plants diseased by other agents. We conducted controlled experiments to further test pathogenicity between May 2001 and May 2002. Healthy plants were challenged with the pathogen, and the development of symptoms was described and quantified (Rizzo et al. 2002a). The process, known as Koch's postulate, ends with the successful reisolation of the microorganism from artificially infected plant tissue. Because most hosts were tested in separate trials, a comparison of susceptibility levels across hosts is not appropriate, and trial results for each host were analyzed independently.

For most experiments, three genetically different isolates of *P. ramorum* were used: Pr-5 from tanoak, Pr-6 from coast live oak and Pr-52 from rhododendron. Foliage inoculations of 2-to-3-year-old plants were conducted by misting leaves with sterile distilled water and then pinning inoculum plugs to the upper surface of leaves. Sterile agar plugs were used as controls. A plastic bag was then placed over the individual leaves and misted again with sterile distilled water before sealing. Each trial generally consisted of 10 leaves per host species per isolate, plus controls. In all trials, seedlings were incubated for 2 weeks in a greenhouse that was maintained at 68°F to 75°F (20°C to 24°C). For each trial, we re-

corded symptoms, measured lesion length and width and plated pieces of stems or leaves on the selective Phytophthora growth medium PARP to verify presence or absence of *P. ramorum*. All leaf inoculations were conducted at least twice.

Methods for stem inoculations have been previously described (Rizzo et al. 2002b). Seedlings (stem diameter approximately 1 centimeter) of coast redwood and Douglas fir were inoculated with isolate Pr-52 in two separate trials started in January (five seedlings per treatments) and March 2002 (10 seedlings per treatment). Both trials lasted 6 weeks.

All data was analyzed by ANOVA using the software program JMP (SAS Institute Inc., Cary, NC, 1995). In all cases, there were no significant differences between different isolates and the different trials, so data was combined for final analysis.

Symptoms and severity

The symptoms of *P. ramorum* have only been observed on aboveground plant parts such as leaves, branches and stems, regardless of the host (table 1). In several instances, stem lesions end at the soil line. Although *P. ramorum* is deadly on certain oaks (*Quercus* spp.) and tanoak, disease progression and the extent of damage on individual plants of most non-oak hosts is not well characterized yet.

On several ericaceous plant species, *P. ramorum* causes significant foliar blight and branch dieback (table 1). Death of madrone *(Arbutus menziesii)* saplings in less than 4 months was observed in the field (P.E. Maloney, unpublished data) and it is suspected that the pathogen can kill mature madrone trees. Death of mature rhododendrons *(Rhododendron macrophyllum)* has also been observed in Oregon (Goheen et al. 2002). On other hosts, such as bay laurel *(Umbellularia californica)*, California buckeye *(Aesculus californica)* and big leaf maple *(Acer macrophyllum)*, *P. ramorum* appears to be primarily a leaf pathogen with very limited stem infection. Leaf inoculations of all suspected hosts resulted in the formation of lesions, and *P. ramorum* was successfully reisolated from all inoculated hosts (table 2).

TABLE 2. Pathogenicity of *Phytophthora ramorum* on leaves of native California plant species; all have been found infected in the field

	P. ramorum			Control	
Host: common name (species)	N	Percent reisolation	Lesion size, mm* (range)	N	Lesion size, mm* (range)
Bay laurel/Oregon myrtle *(Umbellularia californica)*	28	100	5 (0–15)	8	1.1 (0–2)
Big leaf maple *(Acer macrophyllum)*	42	100	19.9 (1–45)	12	2.7 (0–6)
California black oak *(Quercus kellogii)*	15	100	4.9 (1–14)	6	2.6 (1–3)
California buckeye *(Aesculus californica)*	48	94	13.6 (4.5–29)	18	2.5 (0–9)
Coast live oak *(Quercus agrifolia)*	18	100	2.1 (1–4)	6	1.6 (1–2)
Coast redwood† *(Sequoia sempervirens)*	56	43	4.9 (1–20)	19	1.6 (1–3)
Seedlings	20	100	13.7 (4–21)	20	6.2 (0–11)
Coffeeberry *(Rhamnus californica)*	30	30	4.4 (1–15)	10	2.1 (1–3)
Douglas fir‡ *(Pseudotsuga menziesii)*	58	47	2.01 (1–12)	15	1 (1)
Seedlings	20	75	38 (12–64)	20	9 (0–16)
Evergreen huckleberry§ *(Vaccinium ovatum)*	57	84	15.3 (3–22)	20	2.0 (1–13)
Madrone *(Arbutus menziesii)*	18	100	26.9 (15–47)	6	3.5 (1–10)
Manzanita¶ *(Arctostaphylos manzanita)*	101	82	10.6 (1–23)	34	2.1 (1–6)
Tanoak *(Lithocarpus densiflorus)*	18	100	34.5 (25–48)	6	2.0 (1–4)
Toyon *(Heteromeles arbutifolia)*	44	72	5.4 (1–10)	16	2.3 (1–4)

* The average of lesion length and width 14 days after inoculation, except for coast redwood and Douglas fir, where it is only the length. Mean lesion lengths of *P. ramorum* were significantly greater on all hosts, with the exception of coast live oak and Douglas fir, than those of control inoculations at $P < 0.05$ based on ANOVA with contrasts.

† Fifteen inoculations of individual leaves led to discoloration of two or more adjacent leaves. On one inoculation, 60 mm of the adjacent stem was killed.

‡ Twenty-six of 58 single-leaf inoculations resulted in lesions of 17–85 mm long on adjacent branches (5 mm diameter) even though the lesion length on the inoculated needle was 1 mm and apparently not connected to the longer stem lesions. *P. ramorum* was recovered from 13 of these branch lesions.

§ Typical leaf lengths were 15–20 mm; entire leaves turned black on 72% of inoculations. On three inoculated leaves, *P. ramorum* moved into the stems and caused lesions of 30–50 mm length.

¶ Typical leaf lengths were 15–20 mm; entire leaves turned black on 33% of inoculations. On six inoculations, *P. ramorum* grew through petioles and caused branch cankers of 35–55 mm on the main stem.

Coast redwood. Symptoms on coast redwood are associated with saplings and basal sprouts on large trees. On saplings, *P. ramorum* causes discoloration of needles and cankers on small branches, resulting in an overall decline in tree vigor. The pathogen was isolated from the needles and small branches of 11 coast redwood saplings — about 1 to 6 inches (2 to 15 centimeters) in diameter — at two locations (Jack London State Park in Sonoma County and Henry Cowell State Park in Santa Cruz County). Distinct purple-colored lesions were observed on sprouts in the field and apparently lead to death of the shoots. *P. ramorum* was detected using the PCR diagnostic test from 12 of 90 symptomatic basal sprouts collected at seven locations spanning the known geographic range of *P. ramorum* in coastal California. While it appears that *P. ramorum* may be relatively abundant at these sites on coast redwood, the results also indicate that other causes of sprout mortality may be occurring. Greenhouse inoculations of coast redwood stems and

The broad host range of *P. ramorum*, the variability of symptoms among different hosts and the ability of the pathogen to disperse by air suggests that it may have the potential to cause long-term, landscape level changes in California forests.

leaves caused lesions similar to those observed in the field (table 2). In addition, extensive discoloration of the xylem was noted in sapling inoculations (data not shown).

The importance of *P. ramorum* in the dieback and death of mature coast redwood trees is still uncertain. In January 2002, the dieback of a mature coast redwood in an urban setting in Marin County was reported in the press and attributed by a local arborist to infection by *P. ramorum*. This diagnosis was conducted by a private laboratory and based on detection of a *Phytophthora* species using a nonspecific immunoassay (ELISA). We have confirmed that *P. ramorum* was present in the discolored xylem of the stump of the tree using direct PCR amplification and DNA sequencing. We were unable to directly isolate the pathogen from the discolored tissue, nor bait the pathogen from bark or soil samples taken from the base of the tree. This tree was affected by a concrete patio and driveway and had extensive root rot by two unidentified wood-decay fungi and by a root pathogen known as the oak root fungus or honey mushroom *(Armillaria mellea)*. The role of *P. ramorum* in the development of dieback symptoms on this tree is difficult to determine because of the presence of these other pathogens and abiotic factors. Three other large urban redwood trees in Marin County reported in the popular press to be associated with *P. ramorum* were negative for the pathogen both by PCR analysis and culturing, although all of these trees had extensive decay caused by an unidentified canker rot fungus and *A. mellea*. We have not observed unusual mortality or disease symptoms of overstory coast redwood in natural forests (Maloney et al. 2002).

Douglas fir. The impact of *P. ramorum* infection on Douglas fir is also not yet clear (Davidson, Garbelotto et al. 2002). We recovered the pathogen from infected branch tips of Douglas fir at a single location in Sonoma County. Cankers on small branches 0.2 to 0.4 inches (0.5 to 1 centimeters) in diameter resulted in wilting and dieback of branches and needles. Greenhouse inoculations of individual Douglas fir leaves resulted in discoloration of inoculated leaves and the subsequent dieback of adjacent leaves and twigs. Inoculations of stems resulted in resinosis from the bark, cambial necrosis and dieback, and discoloration of foliage (table 2). Symptoms on Douglas fir do not appear to be common in the field at this time and have not been observed on overstory trees.

P. ramorum epidemiology in Calif.

Across the range of known hosts, we can distinguish two different types of diseases: nonlethal foliar and twig infections, and lethal branch or stem infections. Foliar infections play a key role in the epidemiology of *P. ramorum* by serving as a source of inoculum, which is then spread aerially through rain splash (Davidson, Garbelotto et al. 2002). The most likely dispersal propagules of *P. ramorum*, sporangia and chlamydospores, are readily produced on foliage (particularly of bay laurel / Oregon myrtle and *Rhododendron* spp.), but we have yet to find them on infected oak bark. Therefore, *P. ramorum* epidemics in California oak forests may be driven by the presence and susceptibility of associated plant hosts, not the oaks themselves.

Two recent studies have reported a significant association between the presence of bay laurel / Oregon myrtle trees and *P. ramorum* infection on certain oaks *(Quercus* spp.)(Swiecki and Bernhardt 2002; Kelly and Meentemeyer 2002). Likewise, our preliminary studies indicate that foliar host infection may precede infection of oaks *(Quercus* spp.) and tanoak on a site. We hypothesize that *P. ramorum* may need to produce inoculum on the leaves of these associated hosts to serve as a springboard to oak species. Hosts with relatively small lesions may be especially important in the transmission biology of *P. ramorum* because such lesions do not kill leaves but can support abundant sporulation for extended periods of time.

Multiple plant hosts and epidemics. The hypothesis that *P. ramorum* may need multiple plant hosts to cause epidemics is also supported by the results of molecular genetic analyses of *P. ramorum* populations. Genetic fingerprinting on a number of California, Oregon and European isolates is under way using a technique called amplified fragment length polymorphisms (AFLPs)(Vos et al. 1995). Recent studies (Garbelotto et al. 2001; unpublished data) reveal that a single individual of *P. ramorum* has been clonally reproducing and is responsible for over 80% of all infections in California and Oregon. The genetic analysis confirms that the same individual is capable of infecting all hosts. This result is significant because identical-looking pathogens isolated from different hosts may represent undistinguishable but genetically different microorganisms. In addition to the results stemming from the genetic analyses, inoculation of all hosts with cultures isolated from oaks and rhododendron always resulted in typical disease symptoms (table 2). Such data strongly suggests that the pathogen moves from one host to another with no evidence of host specificity for different isolates.

The establishment and spread of *P. ramorum* may be mediated by foliar infections on a variety of hosts. Furthermore, both reproductive (such as sporangia) and resting (such aschlamydospores) structures have been found to accumulate in soil and water (Davidson, Rizzo et al. 2002). Preliminary results indicate that plant material can become infected if placed in contact with infested soil or water, which are likely to play an important role both in the natural and artificial transmission of this pathogen.

Temperature and moisture. The presence of *P. ramorum* has been confirmed in 12 California counties: (from north to south) Humboldt, Mendocino, Sonoma, Napa, Solano, Marin, Contra Costa, Alameda, San Mateo, Santa Clara, Santa Cruz and Monterey. The levels of infestation vary significantly among counties. While large areas within Marin, Santa Cruz, Sonoma and Monterey counties are severely affected, the disease is still sporadically present in all other counties. It has been hypothesized that *P. ramorum* may

Natural spread of the disease in California will be affected by weather patterns and by presence of genetic resistance in susceptible hosts.

thrive in cool and moist environments; if so, the extent and severity of diseases that it causes may be correlated to temperature and moisture conditions.

P. ramorum growth is optimal at temperatures between 64.4°F and 71.6°F (18°C and 22°C)(Werres et al. 2001). Laboratory trials recently showed that the infection rate for bay leaves may average 92% at 18°C, but only 50% and 37% at the less favorable temperatures of 53.6°F and 86°F (12°C and 30°C), respectively (unpublished data). Besides cool temperatures, free water must be present on plant surfaces for efficient infection. *P. ramorum* produces infectious propagules called zoospores, which need to swim in a liquid environment in order to reach a susceptible host. Preliminary studies indicate that a minimum of 6 to 12 hours of free-standing water is required for infection of bay leaves. Rain, fog or dew accumulation may result in the formation of a persistent film of water on plant surfaces.

Studies based on isolations of *P. ramorum* from infested soil indicate that pathogen activity starts after repeated precipitation events and peaks during spring months (J.M. Davidson and P.E. Maloney, unpublished data). Dry and warm weather in the summer and fall result in a sharp decrease and eventually complete arrest of *P. ramorum* activity in soil. Activity of the pathogen on living plants can be inferred by the isolation success of *P. ramorum* from symptomatic plants in the field. Results from 2 years of collections indicated that isolation success from living plants decreases sharply in the summer and fall without ever reaching zero. This is probably because *P. ramorum* is growing in a protected environment within the plant tissue.

Based on the data currently available, the intensity of the disease should be positively correlated with cool and moist conditions. Further research, however, is under way to precisely quantify the parameters associated with disease expression.

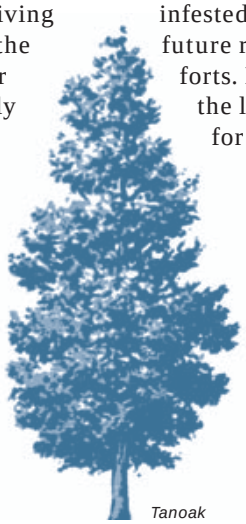
Landscape-level forest changes

A broad host range and predominant clonal reproductive strategy are not unprecedented in the genus *Phytophthora* (Erwin and Ribeiro 1996). *Phytophthora cinnamomi* is known to reproduce mostly clonally and to attack more than 2,000 plant species; it has caused significant ecological damage to forest ecosystems in Australia, Europe and North America. The broad host range of *P. ramorum*, the variability of symptoms among different hosts and the ability of the pathogen to disperse by air, suggest that it may also have the potential to cause similar, long-term, landscape-level changes in California forests. Hosts for *P. ramorum* include canopy trees and understory shrubs. The long-term consequences regarding mortality for non-oak hosts are unknown at this time. However, branch dieback on these non-oak hosts may affect leaf and seed production, negatively impact growth and regeneration, and predispose the plant to attacks by other pathogens and insects. Sublethal infections of non-oak hosts may also allow *P. ramorum* to persist indefinitely in infested forests and affect the success of future regeneration and restoration efforts. It is unclear at this time what the long-term consequences will be for the harvesting and regeneration of coast redwood and Douglas fir. However, the observation of *P. ramorum* in the xylem of a large coast redwood, the results of the inoculation studies for both conifers, and the detection of *P. ramorum* in dying sprouts and branches suggest that the situation requires more extensive research.

The apparent limited gene pool of *P. ramorum* in North America, combined with the extreme susceptibility of some hosts and the pathogen's limited known area of distribution, suggest an introduced organism, but its actual origin and global genetic structure remain unknown. Faced with uncertainty about the origin, distribution and host range of *P. ramorum*, and because many of the known hosts have ranges well beyond California, the United States, Canada, United Kingdom and South Korea have implemented quarantines against movement of certain plant material and/or soil from California and Oregon. The United States has implemented similar restrictions on the movement of potentially affected plant material from Europe. The discovery that even small foliar lesions may potentially be epidemiologically important, combined with the difficulties encountered in culturing the pathogen, is proving to be challenging from a regulatory and monitoring perspective. The use of the DNA-based diagnostic test outlined here offers a reliable approach to detect *P. ramorum*, follow its movement and ultimately understand its biology.

While regulatory actions may prevent the spread of *P. ramorum* to new areas, California coastal forest ecosystems are currently witnessing an expansion of the infestation. Natural spread of the disease in California will


California black oak


Tanoak


Coast live oak


California buckeye

In order to assist the natural recovery of the ecosystem it is essential to fully understand the pathogen's biology and identify forest management approaches that can hinder its spread.

be affected by weather patterns and by presence of genetic resistance in susceptible hosts. Preliminary studies (Dodd and Garbelotto, unpublished data) indicate that individuals of both bay laurel and coast live oak display different levels of disease resistance.

In order to assist the natural recovery of California's forest ecosystems, it is essential to fully understand the pathogen's biology and identify management approaches that can hinder its spread. In Western Australia (Hardy et al. 2001), targeted chemical treatments may have significantly slowed down the spread of the disease. Results from a series of ongoing studies (Garbelotto, Rizzo and Marais 2002) indicate that it may be possible to employ chemical treatments to prevent infection on individual trees (see p. 6). The availability of such treatments, and their careful application, may add a useful tool to an integrated control approach for this ecosystem-level disease.

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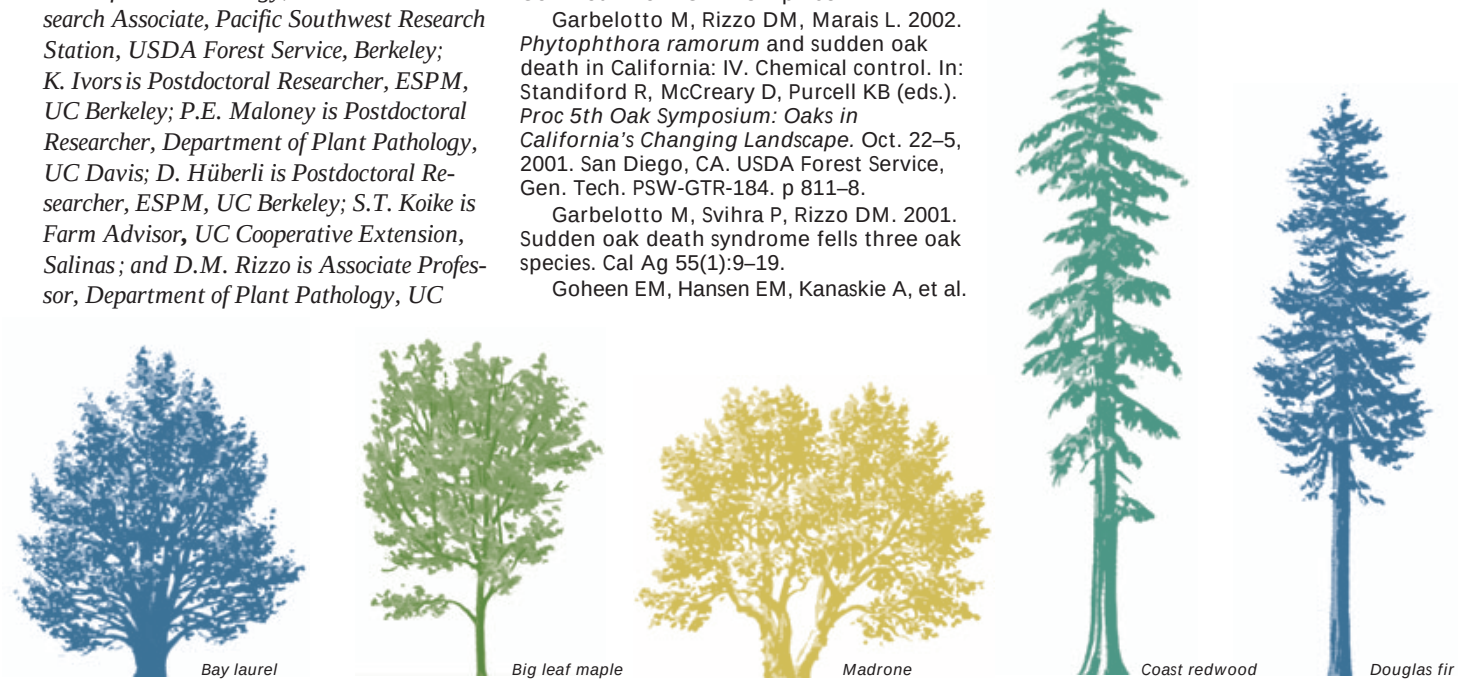

Model describes sustainable long-term recycling of saline agricultural drainage water

John Letey
David E. Birkle
William A. Jury
Iddo Kan

Due to high water tables, the western San Joaquin Valley is prone to high salinity in drainage water, which requires appropriate management and disposal in order to sustain agricultural productivity. We developed a model that describes a farming system for irrigating a salt-tolerant crop with high-salinity drainage water from a salt-sensitive crop. The farming system would include the collection of subsurface drainage water from the salt-sensitive crop, which would then be combined with good, low-salinity water for an average electrical conductivity (EC) of 5 deciSiemens/meter (dS/m); irrigation of the salt-tolerant crop(s) (cotton, in this case) for several cycles; and final disposal of the drainage water in an evaporation pond. The main benefits of this system are that the proportion of the farm required for evaporation ponds decreases and fresh water is saved. According to our calculations, this farming system could be physically sustainable for centuries. However, the costs related to mitigating wildlife impacts caused by ecotoxic salts such as selenium in the evaporation ponds must be fully evaluated to determine the system's economic viability.

Jack Kelly Clark

In regions such as the western San Joaquin County, where water tables are high, salinity is a significant and chronic problem for agriculture. The authors modeled a system for irrigating a salt-sensitive crop such as tomatoes, *above,* with good-quality, low-salinity water, then recycling the drainage water through a salt-tolerant crop.

Much of the western San Joaquin Valley is plagued by high water tables, which require drainage for sustained agricultural production. The land in this area was formed from materials that in geologic time originated under the ocean, and thus contains high concentrations of chemicals associated with ocean waters. Water percolates through the crop root zone, where some is drawn into the plant via transpiration. The water that remains is more concentrated than that which was applied. It moves vertically through the unsaturated area below the root zone to the saturated zone, where soil pores are all filled with water. The water table forms the interface between these unsaturated and saturated zones. The water in the saturated zone is highly concentrated with salts, including selenium, which has ecotoxic effects to wildlife, especially birds.

In order to effectively drain this huge subsurface "pool" of highly concentrated water, growers in the western San Joaquin Valley have developed subsurface drainage systems. These systems consist of perforated drain lines (tubes) that are buried approximately 6 feet deep and between 250 and 400 feet apart. The water flows into and through the network of tubes to a collection sump where it is pumped to the surface.

The amount of water that leaves the root zone is the same amount as enters the drain system; this water travels through pathways of variable length depending on the location where the water enters the saturated zone and the position of the drain line (fig. 1). As a result, water that originates far from the drain line has a considerably longer distance to travel than water that enters the system from directly over the drain.

Jury (1975) developed a simple mathematical model to calculate chemical concentrations in the drain, which takes into account these variable travel times. This model was used recently (Jury et al. 2003) to calculate the transition time for drainage water to reach steady state in the western San Joaquin Valley. Steady state is the point at which the concentration of salts in the water in the drain line remains the same over time. For large drain spacings typical of those found in this region, such as 400 feet, the model predicted many decades of transition time before steady state could be reached. Prior to this time, the drainage water concentrations are influenced strongly by pre-existing salinity in the saturated zone. A flushing process occurs over time, which explains why selenium continues to occur in drainage

water even though essentially no selenium has been added in irrigation water applied to the soil surface.

All irrigation waters contain some dissolved salts, which become more concentrated as water is removed by the crop via transpiration. The ratio of drainage volume to irrigation volume is called the leaching fraction, which is approximately equal to the ratio of the irrigation water's salinity to the drainage water's salinity in steady state. In the western San Joaquin Valley the concentration of irrigation water is low enough that for typical leaching fractions, the salinity of water leaving the root zone is less than that of the resident groundwater being displaced. In general, more salts are removed in the drainage water than are being applied with irrigation water. As a result, some of the salts stored in groundwater originating from geologic times are mined through the drainage process.

One option for disposing of drainage water is to reuse it on salt-tolerant crops. For this type of operation, however, the water percolating below the root zone would be very high in salinity because of the initial high salinity of the applied water and the concentrating effects of water removal by the plant. In this case, the concentration leaving the root zone would be higher than the resident groundwater, so that salts would be stored in groundwater.

The combination of irrigating salt-sensitive crops with good-quality (low salinity) irrigation water and then irrigating salt-tolerant crops with the resulting drainage water creates a cyclic process in which salts are first extracted from groundwater and subsequently recharged to it. However, since there is a continual input of salts to the valley through imported irrigation water, salts gradually accumulate in the system and eventually must be disposed of in some manner.

We simulated the long-term consequences of a farm system that included irrigating salt-sensitive crops with good-quality water (EC [electrical conductivity] = 0.6 deciSiemens / meter [dS / m], a standard measure of water salinity), followed by irrigating salt-tolerant crops with a blend of drainage and good waters, and eventually using an evaporation pond for ultimate disposal of the salts. The imposed conditions, typical of normal farm operations, included planting only economic crops and restricting yield reductions to less than 10%.

Simulation conditions

Water leaving the root zone at a location a short distance from the drain reaches the place of removal in a relatively short time, whereas it may take considerably longer (several years) for water originating at greater horizontal distances from the drainage line to arrive (fig. 1). As a result, at any given time following the start of an irrigation operation on a field overlying saline groundwater, the drain will contain a mixture of water originating from the irrigation and resident groundwater. Using the Jury (1975) method, it is possible to calculate the fraction of water in each category removed by the drain as a function of time.

The percentage of water collected in the drainage system that comes from the root zone can be expressed as a function of a term (T) where $T = 2Qt/\theta S$, and Q is deep percolation in acre-feet / acre / year, S is drain spacing in feet, θ is the saturated water content of the soil, and t is the time in years (fig. 2). This relationship depends upon the ratio of drain spacing (S) and depth (D) to an impermeable / restricting layer. Note that it can take a number of years before the water collected in the drain line originates entirely from the root zone. For example, if S = 400 feet, Q = 1 foot / year, θ = 0.5 and T = 1, then t = 100 years. The time increases with the drain-line spacing and / or depth to the impermeable layer.

Because the Corcoran clay layer — the restricting layer — is very deep compared to the region's typical drain spacing, our computations were done for the curve where $S/D = 1$. The Jury et al. (2003) model makes a number of simplifying assumptions, including neglecting groundwater movement. However, the effect of moving groundwater, if any, would be to decrease the amount of drainage water in the drain compared to resident storage, delaying the time needed to reach steady state indefinitely. Neglecting its effect is therefore conservative. Other influences such as the spatial variability of

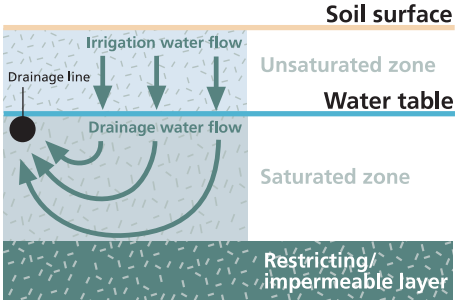

Fig. 1. Irrigation water flows vertically from the soil surface through the unsaturated zone and then moves horizontally through the saturated zone toward the drainage line.

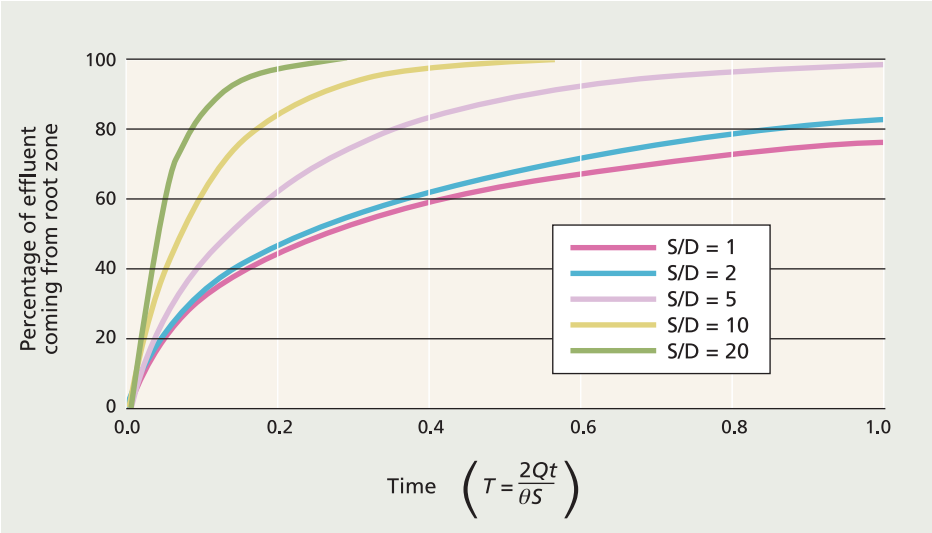

Fig. 2. Percentage of drain effluent collected in the drainage system that comes from the root zone; this relationship depends upon the ratio of drain spacing (S) and depth (D) to an impermeable layer. $T = 2Qt/\theta S$, where Q = deep percolation (acre-feet/acre/year), S = drain spacing (feet), θ = saturated water content of soil, and t = actual time in years.

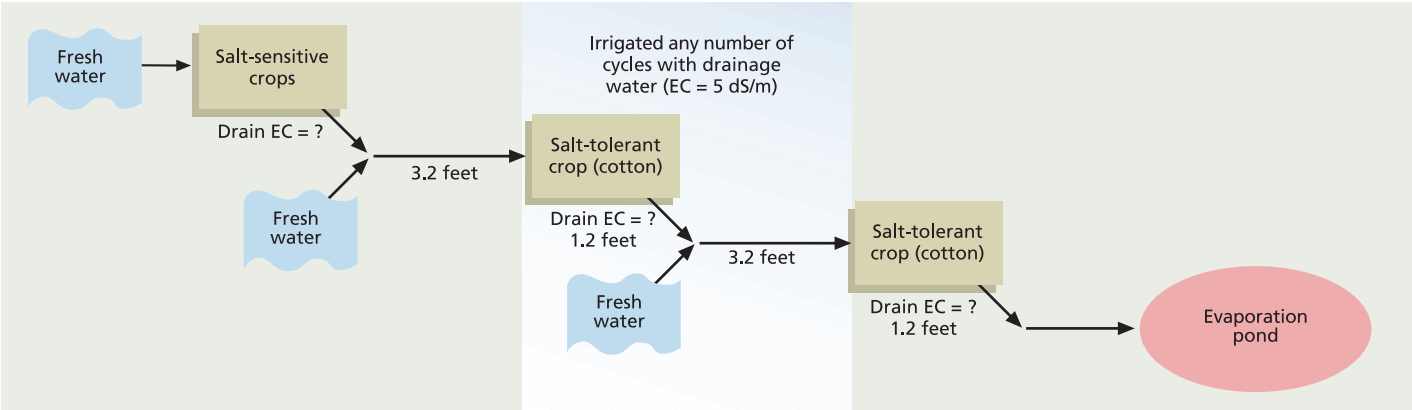

Fig. 3. A model drainage-water reuse system for economically productive crops (EC = electrical conductivity).

soil properties are site specific; but, if random they would not affect travel paths appreciably.

The salinity of drainage waters in the valley typically creates an EC approximately equal to 10 dS/m. We assumed that the drainage water initially collected from the salt-sensitive crop would be at this concentration. Since irrigation water salinity of 10 dS/m is very high for irrigating cotton, our simulation assumed that drainage water and good water would be combined to an average of 5 dS/m. For this analysis, we relied on Letey and Dinar (1986) for the relationships between cotton lint yield and the amount of water applied at various irrigation water salinities. Furthermore, the uniformity of irrigation affects the relationship between yield and the amount of applied water (Letey et al. 1984). We assumed a Christiansen's uniformity coefficient (CUC) equal to 70, which is typical for a furrow irrigation system. We also assumed that the cotton irrigation would produce a lint yield equal to 92% of maximum potential yield. These conditions specified that a total of 3.2 feet of water would be applied, resulting in 1.2 feet of deep percolation (fig. 3).

We assumed two irrigation management cases for the salt-sensitive crop area. One produced 8.8 inches per year of drainage water, and the second imposed a high level of irrigation management that resulted in 4.4 inches per year of drainage water. The EC of the water collected in the drainage system was computed each year using the travel time information in figures 1 and 2. The EC of the drainage water from the salt-sensitive crop area would decrease with time because the salinity of the water leaving the root zone would be less than the resident groundwater's salinity.

The EC of the water collected in the drainage system would dictate how much good-quality water should be used to achieve an average of 5 dS/m irrigation water for cotton. Rainfall that did not evaporate during the winter would provide a fraction of the "good quality" water. As the EC of the drainage water decreased, the required amount of good water decreased. The EC of the drainage water from cotton was calculated yearly. In this case it increased with time, and relatively more good water was required to achieve the average 5 dS/m water. The analyses were done for various numbers of reuse cycles on cotton before the drainage water was disposed of in an evaporation pond.

Irrigation management practices

We calculated the percentage of the farm that could be retained in salt-sensitive crops — such as tomatoes — for up to 100 years, when the drainage volume from the salt-sensitive area is 8.8 inches per year at various numbers of times that it is recycled through cotton (fig. 4A). Increasing the number of cycles decreases the fraction of the farm that can be retained in salt-sensitive crops. However, cycling the drainage water through cotton also decreases the percentage of the farm that must be devoted to evaporation ponds (fig. 4B). We assumed that evaporation from the ponds was 4 feet per year.

Imposing good irrigation management that reduces drainage volume to 4.4 inches per year increases the percentage of the farm that can be planted in salt-sensitive crops (fig. 4C). When compared with drainage of 8.8 inches per year (fig. 4A), decreasing the drainage volume from the salt-sensitive crop area also reduces the percentage of the farm that must be devoted to evaporation ponds (data not shown).

As expected, increasing the number of reuse cycles increases the percentage of the farm that must be devoted to cotton, at 8.8 inches per year of drainage water from the salt-sensitive crop area (fig. 4D). If the drainage water from the salt-sensitive crops is reduced, the percentage of the farm devoted to cotton could also be reduced.

Cotton is a common crop in the western San Joaquin Valley and is usually irrigated with good-quality water. In our scenarios, drainage water was partially used to irrigate the cotton. Therefore, we computed the difference in the amount of good water that

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A system employing furrow irrigation of salt-tolerant cotton, *above,* with a combination of saline drainage water and fresh water could theoretically be sustainable for many decades. However, the costs of disposing salts accumulated in evaporation ponds and related wildlife impacts must be carefully considered.

would be used for cotton with and without blending in drainage water. The difference between these two numbers is considered the amount of fresh water saved by using the drainage water. On a 1,235-acre farm, the increase in acre-feet of fresh water saved by increasing the number of cycles is partially attributed to the fact that more land was also farmed to cotton (fig. 4E).

There are two benefits to recycling drainage water through cotton: the percentage of the farm required for evaporation ponds decreases and fresh water is saved. The monetary value of the water saved depends upon whether the returns are simply associated with applying less fresh water or whether the fresh water can be marketed and sold to the urban sector, where its value is greater. If this is possible, cycling drainage water through cotton could produce significant revenue to offset some of the costs associated with total farm operations.

Long-term system sustainability

The results of this simulation indicate that a system which irrigates salt-sensitive crops with good-quality irrigation water and reuses the drainage water to partially supply water for a salt-tolerant crop, with eventual disposal into an evaporation pond, can be physically sustained for centuries in the western San Joaquin Valley. Management to reduce drainage volumes from the salt-sensitive crop area has a high payoff, in that it allows a greater percentage of the farm to be maintained in salt-sensitive crops and a lower proportion to be devoted to evaporation ponds. Although cotton was selected for this analysis, any salt-tolerant crop could be substituted.

A critical feature of this operation is that evaporation ponds are necessary to ultimately dispose of accumulating salts. It is possible to utilize solar evaporator ponds, in which the drainage water is discharged at rates equal to or less than the evaporation rate. We know of no other option for disposing salts on farmland while maintaining high crop productivity on the major part of the farm. Because of selenium in drainage water, evaporation ponds must also be managed to mitigate wildlife hazards. This may require netting the ponds and/or a combination of management and compensation habitat. The costs associated with the mitigation procedures depend on the extent to which they are required. Therefore, although this system is physically sustainable for centuries, its economic sustainability must still be evaluated.

In areas where the selenium concentration in drainage water is particularly high, the selenium concentration in the evaporation pond could exceed the level established for classifying water as a toxic waste, greatly increasing costs and perhaps making the system economically unfeasible. The criteria used to classify selenium-tainted water as toxic waste play a critical role in future opportunities to maintain agricultural production in a sustainable manner without out-of-valley disposal of drainage waters.

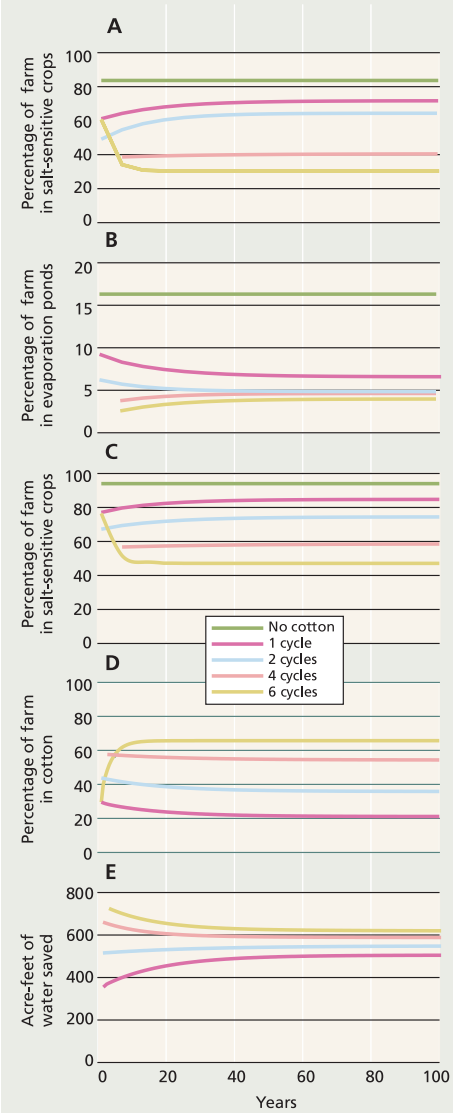

Fig. 4. Over a 100-year period for various numbers of times drainage water is cycled through salt-tolerant crops, the percentage of a model cotton farm with furrow irrigation that could be retained in (A) salt-sensitive crops (with drainage volume of 8.8 inches/year), (B) evaporation ponds (drainage volume, 8.8 inches/year), (C) salt-sensitive crops (drainage volume, 4.4 inches/year), or (D) cotton (drainage volume, 8.8 inches/year), as well as (E) amount of fresh water saved (drainage volume, 8.8 inches/year).

The current soluble threshold limit concentration (STLC) for classifying selenium as toxic waste is 1.0 mg/L. This STLC was derived by multiplying the California drinking water standard for selenium by an environmental accumulation factor of 100. The California drinking water standard was 10 mg/L in the early 1980s when the hazardous waste limits were adopted. The drinking water standard has since been changed to 50 mg/L, but the STLC was not adjusted.

Since wildlife must be protected at concentrations that are orders of magnitude less than the STLC, raising the STLC would have no impact on hazards to wildlife. Indeed, increasing the legally defined STLC would have an insignificant impact on environmental hazards but would facilitate opportunities to maintain an economically sustainable agriculture production system in the western San Joaquin Valley.

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Prospects for integrated control of olive fruit fly are promising in California

Jack Kelly Clark

NEW PESTS and PLANT DISEASES

California's olive industry, which produces table olives and oil, is threatened by the olive fruit fly. A combination of biological and chemical controls may be necessary to achieve effective control.

Timothy R. Collier
Robert A. Van Steenwyk

The recent invasion of California by the olive fruit fly has the potential to devastate commercial olive production throughout the state. Fortunately, much is known about this pest in Europe, and prospects for olive fruit fly control in California are good. Effective management is likely to result from careful monitoring and properly timed chemical control. Suppression of olive fruit fly populations on ornamental and residential olive trees using biological control may also contribute to overall control.

The olive fruit fly was first observed in California in October 1998, when a single female fly was captured in a McPhail trap in west Los Angeles. Over the next 2 months, 126 olive fruit flies were trapped in Los Angeles County. Malathion was applied in and around the capture sites, but by fall 1999 the fly had spread to seven new California counties, including Tulare County in the southern Central Valley. By 2001, the olive fruit fly had spread north of the San Francisco Bay along the coast and to olive production areas in Glenn, Butte and Tehama counties in the northern Central Valley. It now occurs in at least 37 counties in California.

The invasion of California by the olive fruit fly has been both rapid and troublesome for the state's olive industry. In 2001, California growers produced 99% of the commercial olives grown in the United States, 134,000 tons of olives on 36,000 acres for a total value of $90 million (USDA 2002). The olive fruit fly poses a serious economic threat to both table olive and olive oil production in California. In the Mediterranean region, it has been one of the most devastating olive pests for more than 2000 years. Infestation of olive fruit by the larvae causes premature fruit drop and reduces fruit quality for both table olive and olive oil production (Michelakis and Neuenschwander 1983). In table olives, the presence of a few larvae can lead to rejection of an entire crop. Some infestation can be tolerated in olive oil production. However, the presence of larvae and associated microorganisms raises oil acidity and thereby reduces the quality of the oil. Untreated, olive fruit fly may infest more than 90% of olive fruit (Sharaf 1980; Kapatos and Fletcher 1984).

Biology, life cycle and population

The olive fruit fly, *Bactrocera oleae* (Gmelin), belongs to the Tephritidae family of flies, which contains many notorious pests. Olive fruit flies are distinguished from many other tephritid fruit fly species by black spots on the wingtips and the lack of wing banding seen on other tephritid species, such as the apple maggot, walnut husk fly and Mediterranean fruit fly. An adult olive fruit fly is about the size of a housefly, approximately 5 millimeters or three-sixteenths-inch long. Females can be distinguished from males by the ovipositor, a pointed structure at the end of the female's abdomen. Females use the ovipositor to pierce olive fruit and lay eggs just under the skin. Usually, only one egg is laid per fruit, but multiple eggs may be laid in varieties that

produce large fruit. Large-fruited varieties are, in fact, preferred over smaller-fruited varieties for egg laying. Under laboratory conditions, an individual female olive fruit fly may lay 10 to 40 eggs per day and a few hundred eggs in her lifetime (Tzanakakis 1989).

The main host plant of the olive fruit fly is the cultivated olive, *Olea europea L.*, though other trees in the genus *Olea* may also be attacked. The most detailed information about olive fruit fly population ecology comes from a series of studies in an unsprayed olive grove in Corfu, Greece (Fletcher et al. 1978; Fletcher and Kapatos 1981; Kapatos and Fletcher 1984). Olive fruit fly dynamics are likely to be similar in California, although this remains to be determined. Adult flies first emerge in the spring (March to May). This generation attacks olives remaining on the tree from the previous season. During early summer when temperatures are high, days are long and few mature fruit remain on the trees, adult female olive fruit flies enter a state of reproductive diapause in which they have few or no mature eggs (Fletcher et al. 1978). This period is thought to be a time of adult dispersal. In Corfu, Greece, marked females dispersed an average of 440 feet per day during early summer, while males averaged 340 feet (Fletcher and Kapatos 1981).

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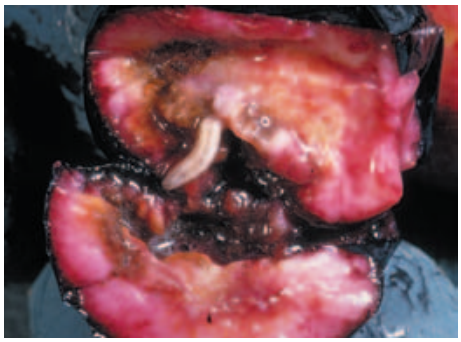

Olive fruit fly females lay their eggs under the skin of fruit. The larva, *above,* infest mature olives with brown internal decay, causing premature fruit drop and potentially contaminating entire crops.

Jack Kelly Clark

The adult olive fruit fly is three-sixteenth-inch long with black spots on the wingtips.

As the new crop of olives develops over the summer, female flies "break" reproductive diapause, produce eggs and become attracted to olive fruit. They lay eggs in the ripening, susceptible olive fruit starting in July, when the pits begin to harden. Multiple generations of the fly may occur over the ensuing summer and fall. Larvae produced during the summer and early fall pupate in the fruit and emerge later in the season. Larvae produced during the late fall pupate in the soil, where they spend the winter. Although the olive fruit fly does not have a true diapause, development is sufficiently slowed during the winter, that pupae produced in late fall do not emerge until the following spring. Olive fruit flies also overwinter as adults and to a lesser extent as eggs and larvae in unharvested fruit (Kapatos and Fletcher 1984).

The phenology of the olive fruit fly seems to be influenced by weather. Hot and dry summer conditions may reduce the buildup of populations on the new crop. During a cool summer in Corfu, Greece, for example, the number of larvae peaked at about 11,000 per tree in mid-August and then peaked again in late September at 18,000 per tree (Kapatos and Fletcher 1984). In the following year the summer was considerably hotter, and after an early peak of about 8,000 larvae per tree in late July, fewer than 4,000 larvae per tree were observed for the remainder of the year. This observation may have reflected that egg and larval fruit flies experience high mortality during hot, dry weather (Kapatos and Fletcher 1984). There may have been an effect of reproductive diapause, which may be prolonged under hot and dry conditions even when ripe olive fruit are present (Fletcher et al. 1978). We might therefore expect dramatic differences in population dynamics in the various olive production areas in California, such as in cool, coastal San Luis Obispo County versus relatively hot, inland Tulare County. Such phenological differences are likely to have important implications for control, but have not yet been investigated in California.

Monitoring and chemical control

Adult olive fruit fly populations are typically monitored using yellow sticky traps baited with sex pheromone and/or ammonium bicarbonate. Sex pheromone is attractive to male flies whereas ammonium bicarbonate is primarily attractive to females. Female fruit flies need protein for egg production and are attracted to ammonia, a volatile compound associated with protein decomposition. Both sexes are attracted to the trap's yellow color. Trap catches may vary in response to numerous variables, including temperature, humidity, physiological status of the fly and, of course, population size (Economopoulos 1979). Nevertheless, monitoring populations using sticky traps can be useful in timing insecticide applications. Such practice is widely used in Europe, where insecticide applications are made on the basis of threshold trap counts.

In Europe, the olive fruit fly is largely controlled using full cover sprays or bait

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Since the olive fruit fly was discovered in California in 1998, it has spread quickly to at least 37 counties. This persistent pest has damaged olive crops for several thousand years in the Mediterranean. In San Diego County, a row of olive trees is infested.

sprays containing organophosphate insecticides, either dimethoate or fenthion (P. Vergoulas, personal communication). One or more cover sprays may be applied during a season. Because of different preharvest interval requirements, fenthion is applied early in the season and dimethoate later. Bait sprays are typically applied repeatedly over the season, with the number of applications depending on location, trap counts and whether the fruit is intended for oil or table olives. In cooler areas (such as Crete and Croatia), seven insecticide-bait applications are made per year versus only two to three applications in hot, dry locations (such as central Greece and Spain; P. Vergoulas, personal communication). Bait sprays capitalize on fruit flies' attraction to protein, a major component of the bait. The flies feed on the insecticide in the bait and die.

Recently, the insecticide spinosad has emerged as a replacement for organophosphate insecticides in bait sprays worldwide. Because neither fenthion nor dimethoate is registered for olive fruit fly control in California, spinosad is used exclusively here. Spinosad is a microbially derived compound that has low toxicity to vertebrates but high toxicity to a number of fruit fly pests. Spinosad mixed with a new fruit-fly bait developed by Dow AgroSciences is currently registered in California under the trade name GF-120 on an emergency exemption (section 18). In California table olives, GF-120 is typically applied weekly from pit hardening (mid-June) until harvest (mid-September). Because olives grown for oil production are harvested later than table olives, additional GF-120 applications may be required. Spinosad bait sprays have been used on an experimental basis in Greece and shown to be as effective as organophosphate insecticide-bait sprays. The efficacy of GF-120 under California conditions has not yet been demonstrated.

Another promising method of olive fruit fly control is the use of attract-and-kill stations, which consist of a yellow plywood, paper or cardboard panel impregnated with a pyrethroid insecticide (deltamethrin) and baited with sex pheromone and/or ammonium bicarbonate (Broumas et al. 2002; Haniotakis et al. 1986). Attracted by the pheromone, ammonia and/or yellow color, flies land on the pyrethroid-impregnated panel and receive a lethal dose of insecticide. Attract-and-kill stations are not sticky and so are effective for an extended period of time. They have shown good efficacy for olive fruit fly management in Greece (Broumas et al. 2002; Haniotakis et al. 1986). Manufactured attract-and-kill stations are not yet registered for use in California.

Prospects for biological control

In the Mediterranean and sub-Saharan Africa, the olive fruit fly is attacked by a number of parasitoid species. The best-known is a braconid wasp, *Psyttalia* (or *Opius*) *concolor* Szepligeti, which was introduced into Italy from Africa in 1914 (Clausen 1978). *P. concolor* was later introduced to France and Greece, and most recently in California. This species is believed to be relatively ineffective as a biological control agent in Europe. One reason for its poor performance may be a lack of synchronization between the life cycles of the parasitoid and fly (Clausen 1978). Olive fruit fly larvae are typically unavailable for parasitism when female *P. concolor* emerge in the spring. Whether this species is similarly limited in California or even has become successfully established here has not yet been determined.

There is still great potential for biological control of olive fruit fly. Several parasitoid species — including at least six additional braconid wasps (K. Hoelmer, personal communication) — are known to attack the pest in Africa but have not yet been established in Europe or California (Wharton and Gilstrap 1983). Researchers from the U.S. Department of Agriculture and California Department of Food and Agriculture are currently working toward importing natural enemies for biological control in California. It is hoped that one or more parasitoid species will lead to some degree of effective control. Total economic control in commercial olive groves may be difficult due to the commercial requirement of very low infestation levels. However, introduced natural enemies may be important in suppressing populations on untreated, residential trees, which undoubtedly serve as a source reservoir of adult flies that disperse into commercial groves.

(continued on back cover)

2 0 0 2 I N D E X

The following research articles, news stories and editorials appeared in *California Agriculture,* Volume 56, Numbers 1 through 6, January through December 2002; numbers are *Jan-Feb* (1), *Mar-Apr* (2), *May-June* (3), *July-Aug* (4), *Sept-Oct* (5) and *Nov-Dec* (6). Back issues may be purchased for $5 per copy, while supplies last; make checks payable to UC Regents.

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Management in California

Since the outbreak was discovered, the California Department of Food and Agriculture has spent about $1.5 million on olive fruit fly control and $150,000 for monitoring. In November 2002, California olive growers requested about $900,000 in federal funding for trapping activities and a computer-based information-sharing system, as well as research on biological control, integrated pest management, and fly behavior and biology. The California Olive Committee recently received a $250,000 research grant to determine the pest's seasonal population dynamics.

Research on the olive fruit fly in California is still in its infancy. Much is known about the fly in Europe, particularly in Greece. California growers and researchers can benefit greatly from this wealth of information. Nevertheless, conditions in California are different, and much research remains to be done. Because insect pests are most effectively managed using carefully timed insecticide applications, research is needed on the phenology of the olive fruit fly in California, particularly in areas with different environmental conditions. In addition, the optimal timing and concentration of GF-120 applications have not yet been determined in California, nor has the potential use of attract-and-kill stations been explored. Finally, the importation of effective biological control organisms may be valuable, particularly in the suppression of residential populations. Potential agents must be evaluated, screened and released. We feel that effective management of olive fruit fly will ultimately be achieved through the development of an integrated pest management program that combines sound monitoring, and implementation of chemical and biological control.

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COMINGUP

Soil quality and sustainability

Soil is the basic building block for maintaining healthy and sustainable natural ecosystems and agricultural production. In the next issue of *California Agriculture*, UC scientists examine how California's soil quality is affected by crops, tillage, grazing and other land uses.

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