

# California Agriculture

*Food policies, food choices:*  
Market incentives for health

## California Agriculture delivers access to peer-reviewed research

In an era of publisher consolidation, when soaring journal prices increasingly limit the availability of science to those who can pay for it, the role of *California Agriculture* and other open-access journals is more important than ever — to deliver peer-reviewed science to the people who need it.

This year *California Agriculture* turns 60, making it one of the nation's oldest, continuously published land-grant university journals. With more than 14,000 domestic and international subscribers, and the full text posted on the Web since 2000, it is also one of the most widely disseminated journals of its kind.

*California Agriculture* and other land-grant publications have long been in the vanguard of those who delivered original, peer-reviewed research to subscribers without charge. (Although foreign subscribers pay a nominal fee, the journal is sent without charge to 1,200 foreign libraries.)

At one time, universities and nonprofit scientific societies published virtually the entire body of original, peer-reviewed research. In recent decades, the explosion of research has overwhelmed such traditional outlets and there are now tens of thousands of academic titles in circulation, many of them copyrighted by private corporations — with access granted to paying subscribers only.

The UC Office of Scholarly Communication notes that science, technology and medical publishers realize 20% to 30% annual profits in return for their massive publishing efforts (<http://osc.universityofcalifornia.edu/>). But a “merger effect” has also led to surging prices, creating a crisis in university libraries across the country.

Libraries have had to cancel journals and cut back book purchases, to keep up with the most essential online subscriptions and journals. Between 1986 and 2002, subscription costs increased 3.5 times the rate of inflation. Collectively, the UC libraries spent about \$64 million for scholarly materials in 2003; UC Berkeley pays over \$900,000 a year to just one publisher.

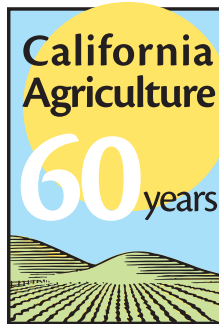
For individuals not affiliated with universities, the cost of downloading a single article can be as high as \$35, an expense compounded by the fact that vast sections of the literature are excluded for proprietary reasons from any one search. Such costs and restrictions are major obstacles to timely, comprehensive sharing of scientific information.

Universities and scientists have begun to counter this trend by taking control of their own research and publishing it in open-access journals or on unrestricted databases.

One such effort is UC's California Digital Library, whose eScholarship Repository supports the publication of journals and other scholarly materials from UC research units (<http://www.cdlib.org/>). Since its establishment in 2000, the Repository has logged over 2.2 million full-text downloads. *California Agriculture's* peer-reviewed articles will soon be posted at this site.



Janet White  
Executive Editor  
*California Agriculture*



Another example is the open-access journal *PLoS Biology*, launched in October 2003 by the Public Library of Science. Evidence that scientists support such efforts came recently when the Institute for Scientific Information ranked *PLoS Biology* in the top tier of life science journals after just 2 years of operation. (The ranking is based on “journal impact factor,” the average number of citations by other scientists per article.)

The commitment of faculty authors, associate editors and reviewers to research dissemination is also evident in every edition of *California Agriculture*. Just as it is critical to provide scientists comprehensive access to disciplinary research, it is equally important to deliver peer-reviewed science to the people who need it outside the research laboratory.

Although 31% of our audience consists of faculty and research scientists, the balance is a diverse mix of growers, private and public sector professionals, and elected officials and staff, all of whom can apply the research, whether in food and fiber production, environmental protection, human and community development, or public policy and mass media communications.

*California Agriculture* performs a broader educational function than faculty normally can achieve with technical publication in a disciplinary journal. It extends significant new findings to a wider readership, informing leaders and decision-makers who are not in the same disciplinary field of important developments. Among articles in this issue, for example, are several that examine our food decisions as a nation, from those made in Congress to those made by consumers in the grocery store.

As California's population has increased and diversified, *California Agriculture's* content has broadened to encompass the entire “culture” of agriculture — forestry, biodiversity, global warming, urban encroachment, hunger, diabetes and the obesity crisis, food safety, demographics, land use, biotechnology, and more.

The journal's authors and reviewers have also become more diverse. Today 18% of our authors are from outside ANR, whether from UC at large, other universities, public agencies or the private sector. In addition, 12% of reviewers are from outside the Division. Rigorous peer review results in 35% of articles being rejected or returned for resubmission.

The last stage of research is its dissemination, and the work of science is not complete until it has reached the hands of the people who can use it. *California Agriculture* is honored to be a part of the continuing tradition of delivering scientific research to the people whose tax dollars have already paid for its generation.

*(Tell us why you read California Agriculture, and what you want to see in these pages in the future. We have posted a survey at <http://californiaagriculture.ucop.edu>. You may also e-mail us at [calag@ucop.edu](mailto:calag@ucop.edu) or write us at the address opposite. —Ed.)*



# California Agriculture

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**COVER:** With rates of obesity and nutrition-related diseases skyrocketing, scientists and policy experts have proposed agricultural policies that would encourage consumers to make healthier food choices. In this issue, a panel of experts debates how the next Farm Bill could affect the state's diversified agriculture with its hundreds of specialty crops (page 5), and a policy analyst argues for market incentives to encourage better nutrition among food stamp recipients (page 8).

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## WHAT DO YOU THINK?

The editorial staff of *California Agriculture* welcomes your letters, comments and suggestions. Please write to us at [calag@ucop.edu](mailto: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.

## Lessons of U.S. BSE policy

Regarding the October-December 2005 issue ("Testing times: The impact of mad cow disease"): A number of lessons can be drawn from the BSE story. First, purse strings and market concerns rather than public health guide public policy on BSE. Second, the dangers inherent in industrial agriculture are not the same risks inherent in organic agriculture. And finally, the farm lobby is a threat to food security.

The bigger picture of U.S. agriculture also surfaces in the BSE lessons. Industrial agriculture reduces the farmer and rancher to blue-collar workers whose only ethic is the dollar. Sustainable and organic farmers and ranchers are professionals, professing a code of conduct that includes both food quality and social justice. Had the organic industry been as large as industrial agriculture, the odds are good that the United States would have had better BSE surveillance, earlier cases and more statistics than now.

Bud Hoekstra  
San Andreas

*Editor's note: Mr. Hoekstra provided a detailed analysis as the basis for these opinions, which we did not have the space to print.*

## Influence of hort biotech issue

This letter is to commend *California Agriculture* on publishing the special issue, "Fruits of Biotechnology Struggle to Emerge" (April-June 2004). This publication has been widely distributed and highlighted at several important agricultural events in California, the United States and internationally, and the ideas have been incorporated in a range of other publications. Some specific outcomes from the special issue include:

- The Seed Biotechnology Center and Agricultural Issues Center at UC Davis have distributed more than 1,600 hard copies at public and private meetings and have directed many inquiries to the electronic version available from the *California Agriculture* Web site.
- The material in this issue formed the basis of public comments to the U.S. Department of Agriculture in 2004 on the regulation of biotech crops in the United States, which were subsequently expanded and published in *Nature Biotechnology* in April 2005 (23:439-44).
- The material was cited extensively in articles in *Chronica Horticulturae* (2004, 44:4-8) and the *Journal of Crop Improvement* (in press), and in a book chapter to be published in early 2006



(R. Just, J. Alston and D. Zilberman, eds., *Economics of Regulation of Agricultural Biotechnologies*, Kluwer).

- The special issue supported the rationale for a "specialty crops regulatory initiative" to provide assistance with obtaining approval for commercial releases, particularly for public developers of biotech specialty crops in the United States. Meetings in Washington, D.C., in 2004 and 2005 have further developed this concept into a detailed plan to be proposed at the national level.
- At the recent meeting on the Cartagena Protocol for Biosafety, the agreement that will regulate trade in biotech crops worldwide, the special issue was used by several parties as a reference.

As guest editors of this issue, it was a pleasure for us to work with the *California Agriculture* staff, whose input enhanced the written clarity and visual presentation of the material. We believe that *California Agriculture* can be justifiably proud of producing this high-quality and relevant publication.

Kent J. Bradford  
Professor and Director  
Seed Biotechnology Center, UC Davis

Julian M. Alston  
Professor, Agricultural & Resource Economics, UC Davis  
Associate Director, UC Agricultural Issues Center

## Panoramic California

I want to compliment you on the April-June 2005 issue of *California Agriculture*. I have been a subscriber for almost 40 years and have found much of value through the decades. During our creation of the California Water Atlas in the 1970s, I used your staff and many contributors to ferret out important information.

After more than 30 years on the geography faculty at CSU Northridge, I have retired and immersed myself even more deeply in the geography of California and the West. One of my amusements is the creation of photorealistic aerial panoramas made from mathematical simulations. The data from which these unusual, high-altitude images are constructed come from NASA numerical satellite operations (Landsat 7 and SRTM).

I think that such illustrations might help your authors and readers to better understand the essential spatial qualities of California. All my work is copyrighted, but I give away its limited use to schoolteachers and students for nonprofit, instructional purposes.

William Bowen  
California Geographical Survey, Northridge  
(<http://geogdata.csun.edu>)

*Editor's note: We are grateful to Dr. Bowen for his contribution of the wonderful image on page 7.*

**Correction:** James A. Downer, UC Cooperative Extension farm advisor in Ventura County, was inadvertently omitted from the author list of "Imported parasitic wasp helps control red gum lerp psyllid" (Cal Ag 59:229-34).

## Panel debates next Farm Bill's impact on California

**Editor's note:** This roundtable discussion features the voices of three prominent authorities on the 2007 Farm Bill. Their freewheeling 90-minute discussion took place in the summer of 2005. While participants did not reach consensus on all points, each approved this summary of the discussion and their remarks.

California Agriculture Associate Editor **Alvin D. Sokolow** moderated the session and wrote the narrative.



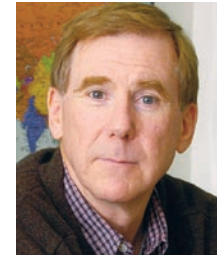
Alvin D. Sokolow



Ralph E. Grossi



A.G. Kawamura



Daniel A. Sumner

If all goes as scheduled, the next federal Farm Bill will be approved by Congress and the President late in 2007. Each Farm Bill updates national agricultural policy, every 5 years or so. The Farm Bill covers a wide swath of programs, regulations and spending — including commodity payments, nutrition, conservation, rural development, energy, trade, research and extension, credit, and forestry. The 2002 legislation authorized a 5-year total of \$422 billion.

What are the key issues affecting California in the 2007 Farm Bill? *California Agriculture* organized a roundtable of panelists to address this question:

- **Ralph E. Grossi**, President, Washington, D.C.-based American Farmland Trust since 1985; third-generation Marin County dairy farmer.
- **A.G. Kawamura**, Secretary, California Department of Food and Agriculture since 2003; Orange County producer of specialty crops.
- **Daniel A. Sumner**, Director, UC Agricultural Issues Center (AIC); Frank Buck Jr. Professor, Department of Agricultural and Resource Economics, UC Davis.

### California's stake in upcoming Farm Bill

California is the nation's leading agricultural state in market value of farm products, with annual on-farm revenue of about \$30 billion. Enhancing agriculture's ability to deliver food, fiber and other products to consumers, while improving the industry's social and environmental performance, is a key objective of the Farm Bill. Panelist Sumner noted that proposals for the 2007 bill include reducing farm commodity payments, supporting removal of export barriers, enhancing control of invasive agricultural pests and diseases, increasing incentives for conservation, and improving nutrition education and information.

**Kawamura:** *In this Farm Bill, you have got new players that want to strengthen the nation's commitment to food security. There is the biotech community; the nutrition community, driven by the obesity crisis and other concerns; the conservation community, which is excited about the fact that there may be more dollars to achieve*

*environmental purposes; and the bio-fuel energy community, which would love nothing more than a commitment to move toward energy self-sufficiency.*

**Grossi:** *At the top of that list is helping farmers and ranchers address conservation and environmental needs.*

### Redirecting commodity payments

A popular perception of federal farm policy in this state is that California gets short-changed in the billions of dollars spent nationally on subsidies to growers. Most of those funds go to a few basic crops — especially corn, wheat, soybeans, cotton and rice — that are produced largely in the Midwest and South, bypassing California's large, diversified agriculture with its hundreds of specialty crops. California annually receives less than 5% of commodity payments while its farm market value represents more than 12% nationwide (table 1). Two-thirds of the commodity payments coming to this state go to producers of two crops, cotton and rice. Panelists discussed how tax dollars could be redirected to support agricultural entrepreneurship and innovation. They also recognized that commodity payments contribute to local economies in rural communities.

**Sumner:** *I think even for the commodities that have been the recipients of the transfers, the evidence that payments have created long-term health for those industries just isn't there. For example, wheat has gotten billions of dollars of subsidies over the last 40 to 50 years, strawberries approximately zero. Has that meant that wheat has been the strong, healthy industry, and strawberries a weak one? The answer is absolutely not. So there is some evidence that you do not build the long-term health of agriculture with income transfers to producers.*

**Grossi:** *There may be a lot of reasons why California farmers are more market-focused and entrepreneurial as a group than farmers in the rest of the country. One reason is that we have not had a lot of farm subsidies. Subsidies tend to dampen the entrepreneurial spirit, because farmers tend to think about how to maximize payments. You have only to look at the change in Iowa over the last 40 or 50 years to realize how less diverse an economy it is, in large*

Suzanne Paisley



An innovative approach will be needed if the 2007 Farm Bill is to promote the growth and consumption of healthy fruits and vegetables, staples of California agriculture.

part because of farm subsidies. What we don't want to see in the next Farm Bill are California farmers wanting those same kinds of subsidies. I would like to see government

support decoupled from specific commodities, because it can have such a distorting influence on markets and individual farmer decisions.

**Kawamura:** However, the commodity payments that go to individual farmers also produce benefits. This money enables us to maintain our agricultural infrastructure and capacity nationally, helping farmers continue to stay in agriculture as opposed to letting their capacity sit idle. In

small communities in Fresno and Tulare counties, and other places in California, there is still a dependency on agriculture doing well.

**Promoting better nutrition**

The Farm Bill also provides for food and nutrition programs, including food stamps, school lunch and food safety. Federal spending on these programs (about \$50 billion annually) actually exceeds commodity payments. Participants discussed the merits of promoting healthy diets among low-income and other consumers, an approach that would also benefit California agriculture (see page 8).

**Kawamura:** Nutrition has to be a global, national and statewide priority. We are excited about how nutrition awareness is growing, that this is the first and foremost investment that countries can make to promote a healthy citizenry. We are also recognizing

the disaster we have in our own country, with obesity and over-eating, as well as malnutrition and hunger in America and other countries.

**Sumner:** The research we have done at the AIC shows that if people shifted their diets toward more fruits and vegetables, California agriculture gains substantially. It will require political leadership if we are to have a nutrition title that really focuses more attention on healthy eating.

**Grossi:** If you accept that large government programs and payments influence human behavior, then the Farm Bill has the potential to have a major impact on dietary habits. Should we have things in the bill that encourage institutional buyers to purchase different kinds of products? Milk instead of sodas, for example?

**Improving conservation programs**

California receives very little of the \$1.8 billion dollars in annual funding from the Conservation Reserve Program (CRP) which pays to idle cropland. California does better from other conservation programs (table 2). Participants commended funding for environmental improvement such as EQIP (Environmental Quality Incentives Program), as well as programs that offer technical assistance to farmers addressing environmental problems. EQIP received high marks because it assists agricultural landowners and operators on a cost-share basis to cope with water and air-quality issues.

Panelists pointed out that while everyone supports the concept of conservation, there is much to be done to improve the efficiency of programs. The CRP, for instance, is less useful to California agriculture because it isn't always reflective of conditions in the state: specifically, rents on land. While the CRP retires land, it does so on a more temporary basis through 10-year contracts. It could be made more flexible by allowing sustainable harvesting of biomass for energy. Also in the research area, panelists said that federal funding to control pests and diseases should be expanded, increasing efforts to control the importation of pests through international trade channels.

**Grossi:** It's very important for us in agriculture to understand that regulation is not going to go away. We fight it at times, but we are living in an increasingly urban and suburban society, with more people living closer to agriculture, as urban sprawl increases. So, the real challenge here is to regulate wisely and balance this increasing regulatory burden with incentives and other compensatory programs that share the cost of achieving environmental goals between farmers who care for the land and the rest of society who reap the benefits.

**Kawamura:** In our department we see that the greater transfer of materials and plant species in world markets leaves California tremendously vulnerable. Pest exclusion and phytosanitary protocols need to be brought

**TABLE 1. States with top commodity payments versus total agricultural market value, FY 2003**

State	Commodity payments*	Farm products market value
..... \$ millions .....		
Texas	1,641	17,966
Arkansas	969	5,900
Iowa	900	13,100
Illinois	799	9,200
Kansas	762	10,300
California	742	29,000

\*Outlays fluctuate from year to year, mainly because of changing commodity prices.  
Source: USDA National Agricultural Statistics Service.

to the forefront in the Farm Bill, especially in a world where you have homeland security concerns as well.

### Enhancing global trade

The 2007 Farm Bill has the potential to enhance the position of California agriculture in international trade. The panel noted that trade negotiations are proceeding at the same time, and reduced commodity subsidies could lead to lowered trade barriers in other countries. The global concerns of U.S. agriculture are as old as the first exports of colonial tobacco in 1608, Sumner noted, but the global interconnections are even more vital now.

**Sumner:** *To get other countries to open their markets, the United States will have to reduce the production incentives built into our farm programs. It's a grand bargain (cutting subsidies to open markets), and our trade negotiators obviously can get more benefit for California agriculture the more they can open export markets for California products. Beneficiaries of lower trade barriers include the cotton and rice industries, which are also very dependent on subsidies. But, lower trade barriers are also a big win for other parts of California agriculture that do not get subsidies.*

### Toward reform: Farm Bill politics

Finally, participants discussed the steps leading to the enactment of the 2007 Farm Bill. Already, at least 18 months in advance of final legislation, a larger and more diverse collection of organized interests than usual is engaged in extensive jockeying to influence the terms of the bill. Fundamental reforms are in the air, making the process unusually complicated and lengthy.

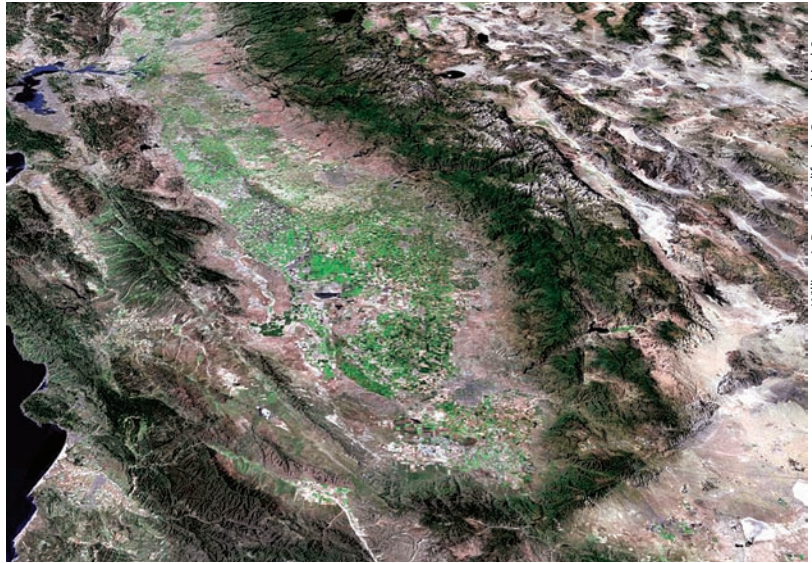
The alliances are coming to the table for different reasons, but many of them believe that a change is coming, and so there are opportunities to shape things in a way that meets their needs.

**Kawamura:** *And with specialty crops newly involved with the Farm Bill, congressional delegations from the affected states may get involved with those negotiations, which would be a huge swing in the nature of congressional participation.*

### What's next?

Considering this mix of issues and forces, it is still too early to discern the shape of the 2007 Farm Bill and its possible effects on California. The large national budget deficit makes it likely that this next bill will reduce current federal spending on agricultural and related programs. Almost all observers expect cuts, especially in commodity payments.

Other critical factors include current World Trade Organization (WTO) rules and ongoing negotiations over a new Agricultural Agreement. Some subsidies by the United States and other nations to their agricultural sectors produce "trade



William A. Bowen/California Geographical Survey

**In the San Joaquin Valley, shown, a predominantly agricultural region is struggling with pressures from increasing population and sprawl development. Federal environmental and conservation law will continue to have an important impact on land use in rural and natural areas of California.**

distortions"; these are vulnerable to challenge as violating the current WTO rules. Furthermore, the trade impact of commodity programs is the key issue currently delaying a final WTO agreement, now anticipated in 2007. The terms of the WTO agreement will certainly affect the amounts and details of commodity payments to U.S. farmers, as the U.S. government wants to ensure that federal farm policy is compatible with international obligations. Sumner noted that some voices in Congress and in the agricultural community are calling for a delay beyond 2007 to complete the upcoming Farm Bill, in order to allow sufficient time to absorb the new international rules.

**TABLE 2. Payments to California farmers by major programs of USDA's Natural Resources Conservation Service, FY 2003\***

Program	Conservation payments† \$ millions
Environmental Quality Incentives Program (EQIP)	33.9
Wetlands Reserve Program (WRP)	19.6
Conservation technical assistance	18.9
Ground and Surface Water Conservation Program	11.5
Klamath Basin Program	6.9
Farm and Ranch Lands Protection Program	3.2
Grassland Reserve Program	2.3

\* The table does not include payments made by USDA's Conservation Reserve Program (about \$1.8 billion nationwide), which is a program of the Farm Services Administration.

† California ranked second nationwide with non-CRP conservation funding of \$97.2 million, 15.4% of national total; Texas ranked first nationwide, with total conservation funding of \$118.4 million, 18.7% of national total. When CRP is included California ranks about 12th and had about 4% of the national total.

Outlays fluctuate from year to year because of changing congressional appropriations and allocation formulas.



# Market incentives could bring U.S. agriculture and nutrition policies into accord

Josh Miner



*The U.S. Department of Agriculture (USDA) could help improve public health by creating a retail-based mechanism to provide participants in its Food Stamp Program (FSP) with significant monetary incentives to purchase health-promoting foods, such as minimally processed fruits, vegetables and whole-grain products. Increasing the consumption of such foods is of immediate importance in combating skyrocketing rates of diet-related chronic diseases such as heart disease, diabetes and obesity, all of which disproportionately affect low-income consumers. This incentive program could be paid for out of the tens of billions of dollars currently spent on annual commodity support payments. The redirected funds could be used to reimburse retailers and wholesaler-distributors for lost revenues, and to provide growers and processors with direct payments. The USDA would do well to consider such an approach because U.S. farm and nutrition policies often lack coherence and are not designed specifically to improve the health of U.S. consumers. This approach would also benefit California specialty crop growers, who currently receive a small proportion of federal subsidies and no direct commodity payments whatsoever.*

*Editor's note: The following article is a peer-reviewed perspective. Perspectives are review articles that interpret and analyze recent developments in research and public policy and express an opinion concerning the resulting impact on California's agricultural, natural and human resources.*



JLP/Sylvia Torres/CORBIS

The author argues that current commodity-support programs do not promote public health goals, such as increasing the consumption of fruits and vegetables.

Every year, the U.S. government authorizes the U.S. Department of Agriculture (USDA) to spend tens of billions of taxpayer dollars to support various agricultural and nutrition programs. Two in particular provoke both ire and unqualified support among elected representatives and other observers: the Food Stamp Program (FSP), which is operated by the Food and Nutrition Service (FNS), and the commodity support program, which is operated by the Farm Ser-

vices Agency (FSA). This is partly due to the fact that the amounts spent are significant, but also because the potential impacts of these programs are questionable and extremely difficult to evaluate.

The Food Stamp Program is designed to augment the food budgets of qualified recipients, allowing them to purchase more food; the commodity support program ensures that commodity growers receive no less than a certain minimum price for their crops,



**TABLE 1. Food stamp benefit distributions, 2003**

	U.S.	Calif.
Total benefits, in \$ millions	21,400	127
No. of recipient households	9,200,000	651,000*
Average household benefit (\$)	195	195

\* California's population comprised 12.2% of the U.S. population in 2003 but received 7.3% of the nation's food stamp benefits.

Source: USDA-FNS 2004.

even though market prices often fall significantly below that "price floor."

### Food stamps for low-income families

U.S. citizens and some permanent-resident aliens are qualified to participate in the FSP if they meet the following criteria: a gross monthly income below 130% of the federal poverty level, and a net monthly income below 100% of the federal poverty level (\$1,698 and \$1,306, respectively, for a family of three in fiscal year 2004-2005, in most places); less than \$2,000 in "countable resources," such as a bank account; the ability to meet work requirements for able-bodied adults; and the ability to provide a Social Security number for all household members. In 2003, the USDA distributed a total of \$21.4 billion in food stamp benefits to a monthly average of 9.2 million low-income households; each received an average of \$195 per month (table 1) (USDA FNS 2004).

Although the food stamp program has been shown to marginally increase the quantity of food consumed by participants, a review of the dietary impacts of U.S. food assistance programs found that "there is no convincing body of evidence that [the FSP] improves the overall quality of the recipients' diet, although there is some indication that it has increased the intake of some nutrients" (Levedahl and Oliveira 1999). (Each additional dollar of food stamp benefits increases recipients' food expenditures by 26 cents; the remaining 74 cents effectively were redirected toward other, nonfood items.)

While the correlation between income level and fruit and vegetable intake has not been examined, the proportion of consumers who eat at least five servings of fruits and vegetables daily is lower among black than white Americans;



Davis Krauter

**By implementing a system of market incentives, USDA could help to improve the "food environment" in low-income neighborhoods (such as, above, West Oakland), where residents often have easy access to liquor and fast food but have a harder time finding healthy, appealing, affordable food.**

likewise, those with less than a high school education consume fewer servings than college graduates (Serdula et al. 2004). Essentially all Americans, and not just food stamp recipients, would benefit from purchasing and consuming more healthful food products. Increasing the purchasing power of low-income Americans, however, is of particular importance due to the fact that calories are most cheaply available in the form of added fats and sugars, while nutrient-dense foods are often significantly more expensive by comparison (Drewnowski and Barratt-Fornell 2004).

Besides not improving participants' dietary quality, the food stamp program also doesn't serve those eligible to receive benefits particularly well: in 2003, only 61% of those eligible nationwide participated in the program, and in California only 39% of those eligible participated (Food Research and Action Center 2003). Low participation rates represent, in the case of California alone, between \$650 million and \$1.49 billion in lost federal dollars annually (California Food Policy Advocates 2003).

There are several explanations for these participation rates. Potential food-stamp recipients often lack knowledge about eligibility criteria. In addition, the

application process is notoriously difficult and dehumanizing, and the benefits are often perceived as not being worth the hassle. There is also persistent, and often well-founded, fear among immigrant communities that undocumented family members will be exposed to the U.S. Immigration and Naturalization Service (INS) by the application process for eligible individuals, such as U.S.-born children. California's large immigrant community is an important factor contributing to the state's low food stamp participation rate.

### Commodity support for growers

Direct commodity support payments are subsidies paid directly by the USDA-FSA to growers of crops such as corn, wheat, cotton, soybeans and rice to offset low prices in the marketplace. These price supports do not in all likelihood significantly affect the retail price of food products, because only a small portion of that price is attributable to the cost of subsidized ingredients. For example, the cost of high-fructose corn syrup in Coca-Cola or of corn in a box of Corn Chex represents only about 1% or less of the retail price.

However, subsidies depress commodity market prices by raising produc-

**TABLE 2. Commodity subsidy payments made to U.S. and California growers, 2003**

	Payment concentration					
	Commodity payments		Top 1% of recipients		Top 20% of recipients	
	U.S.	Calif.	U.S.	Calif.	U.S.	Calif.
Total payment, in \$ millions (%)	11,487	672	3,165 (28)	113 (17)	9,950 (87)	502 (75)
No. of farms (%)	1,556,819 (73)	15,531 (19.5)	15,587	155	311,747	3,117

Sources: USDA-NASS 2004; Environmental Working Group 2004.

tion levels above demand. By keeping commodity prices artificially low, price supports also encourage the use of commodities in processed foods and as animal feed. Because subsidy payments are directly linked to farm production levels and total farm revenues, the program also encourages overproduction (the more a farm produces, the larger the support payment for which it is eligible). The program is popular among large-scale commodity growers, who can receive millions of dollars each year, and legislators eager to show support for American farmers. It was therefore surprising to many that in early 2005 President Bush proposed placing a cap on commodity support payments of \$250,000 per grower. With the recent defeat of the Grassley-Dorgan amendment in the Senate, which would have established a \$250,000 cap on payments, whether that cap will be established will have to wait until the debate on the 2007 Farm Bill begins in earnest (see page 5).

Direct commodity payments are enormous and highly concentrated among the largest and most profitable growers. For example, \$107.3 billion was paid out between 1995 and 2003, with 87% of the \$11.5 billion spent in 2003 going to the top 20% of recipients (table 2) (Environmental Working Group 2004). Agricultural production in California is skewed heavily toward specialty crops such as fruits, vegetables and nuts, which do not qualify to receive direct payments. As a result, fewer California growers are eligible to receive commodity subsidies. In 2003, close to 20% did — mostly growers of rice, cotton and wheat; they received roughly 6%, or \$672 million, of the U.S. total commodity payments in a similarly concentrated fashion (table 2) (Environmental Working Group 2004).

### Stronger links to public health

The food stamp and commodity support programs illustrate that U.S. agricultural and nutrition policies are not specifically designed to promote health or good eating habits. A considerable proportion of commodity payments, for example, is directed to crops that are used primarily to produce calories in the form of added fats (such as corn oil) or sugars (such as high-fructose corn syrup) or as feed for livestock. What's more, the bulk of these payments goes to very large growers of commodities that are overproduced to such an extent that subsidies are necessary to offset low market prices. Similarly, the food stamp program

### Incentives might go a long way toward eliminating two of the main barriers that consumers cite as keeping them from eating a better diet: cost and access.

supplements the incomes of millions of low-income Americans so that they can afford to purchase an adequate amount of calories, but does very little to influence the nutritional quality of their diets.

Unhealthy diets and inadequate fruit and vegetable intakes are the norm among most Americans, and diet-related chronic diseases such as diabetes, heart disease and obesity disproportionately affect low-income Americans. Making healthful foods more widely available and less expensive to consumers would help bring agriculture and nutrition policies into accord with public health goals, and would be good public policy (Nestle 2000). USDA Economic Research Service researchers recently highlighted the potential "unintended consequences" of policies to combat obesity — such as

listing the number of calories on menus at fast-food restaurants or levying taxes on snack foods — and concluded that such policies would in all likelihood not cause consumers to choose healthier foods (Kuchler et al. 2005). These researchers also examined the relative importance of economic and behavioral factors in influencing fruit and vegetable choices (Guthrie et al. 2005). Research has demonstrated that cost significantly influences consumer food choices, especially among low-income consumers, and that retail price reductions are an effective method to increase the purchase of more healthful foods (Glanz et al. 1998; French 2003).

### Incentives to improve nutrition

There is no question that the food stamp and commodity support programs would distribute payments quite differently if the goals of both were explicitly to promote better eating habits among U.S. consumers. Increasing the level of benefits or expanding food stamp eligibility criteria is always a contentious and politically difficult issue. This is truer than ever now, with

pressing fiscal issues preventing the expansion of most federal programs. How, then, can we influence the dietary quality of food stamp recipients, especially given the fact that increased benefits are unlikely to cause recipients to purchase healthier foods?

I argue that the answer lies in creating marketplace incentives targeted to certain products (such as minimally processed fruits, vegetables and whole-grain foods), rather than the current FNS approach of developing nutrition-education and social-marketing messages (such as the 5 A Day campaign for promoting fruit and vegetable consumption). Congress and the USDA could create such an incentive program for food stamp participants by redirecting part or all of the funding currently distributed through the commodity support program. Any cuts or changes to the commodity support program would



To encourage produce consumption among low-income consumers, the USDA could expand its Farmers' Market Nutrition Program, which provides \$20 million in coupons annually to low-income and elderly persons for farmers' market purchases. *Left*, shoppers at the popular Davis Farmers Market.

probably have to be designed to minimize impacts to existing food assistance programs, depending on commodity distribution. For example, some commodities that currently qualify for direct payments — which eventually make their way to entities such as food banks and schools through FNS food distribution programs — could be negatively affected by a reduction in commodity availability and price.

A FSP incentive program could reduce the retail price of healthful food items by providing retailers, wholesaler-distributors and growers with reimbursements and direct subsidies to cover costs and lost revenues. Lower costs would lead to increased demand, which, coupled with targeted subsidies and reimbursements, would act to stimulate production and increase retail access. The enactment of country-of-origin labeling laws would provide a mechanism to ensure that only products of U.S. growers would qualify.

Such an incentive program might work as follows. Food stamp recipients would

receive a significant discount — 50%, for example — when they use benefits to purchase qualified products that meet certain nutritional guidelines at FNS-authorized retail stores. FNS would then direct reimbursements to retailers, wholesaler-distributors and growers to make up for decreased revenues at the retail level. Because roughly 30% of the retail price of fruits and vegetables represents gross retail profits, reducing retail prices by 50% would allow for retail profit margins to remain constant with decreased revenues coming out of product costs, which would be paid by USDA directly to wholesaler-distributors. A similar transfer would occur at the wholesale level, with the USDA paying up to 100% of the amount normally paid to growers — roughly 20% of the retail price.

The USDA would ensure that everyone's gross profit remains constant. To do so, it would actually not need to reimburse the retailer for lost revenues at all (although retailers may need to be reimbursed for some administrative costs). The retailer would continue to purchase

produce from wholesaler-distributors, but a portion of that payment would in fact be made by the USDA, effectively discounting the price for retailers. This would allow retailers to charge customers a lower retail price while paying for costs and generating the same gross profits off larger gross margins, due to decreased product costs. Instead of dedicating 70% of the retail price to pay for product costs, the retailer would now dedicate only 40%, thereby generating the same gross profits off a larger gross margin (60% vs. 30%). The USDA would make payments at the farm gate and at the wholesale level. It would pay the wholesaler-distributor three-fifths of the discount, ensuring that the gross profit at the wholesale level remains equal to what it was before the price was discounted to the retailer. The remaining two-fifths would be paid to the grower, ensuring that their payments remain unchanged as well (table 3).

Needless to say, the exact manner in which the USDA would pay reimbursements would need to be carefully designed and implemented to avoid market distortions and fraudulent activities. Similarly, the method for determining which foods do and do not qualify for discounts would need to be developed by an entity not influenced by the food industry or particular crop associations — perhaps the Institute of Medicine, which was recently charged with reformulating the Women, Infants, and Children (WIC) food package.

### Small and local growers

So far, I have discussed targeting incentives to purchases made only at traditional, FNS-authorized retail outlets such as supermarkets. Such a pro-

TABLE 3. Cost before and after proposed program for 1 pound of apples selling at \$1 per pound

Apples	Before	After
Retail	\$1.00/lb (\$0.70 cost + \$0.30 gross profit)	\$0.50/lb (\$0.20 cost + \$0.30 gross profit)
Wholesale-distributor	\$0.70/lb (\$0.20 cost + \$0.50 gross profit)	\$0.20/lb + \$0.30/lb from USDA (\$0.00 cost + \$0.50 gross profit)
Grower	\$0.20/lb (cost/profit breakdown unknown)	\$0.00/lb + \$0.20/lb from USDA



Changes to commodity support programs would need to be carefully designed to avoid negative impacts on USDA food distribution programs, such as those that serve food banks and schools. However, because such entities are in far greater need of low-cost, fresh produce than they are of USDA commodities, directing subsidies toward produce production and distribution could positively affect these programs as well.

gram would no doubt provide indirect incentives for the expansion of fruit and vegetable production nationwide (among other food products). But because the vast majority of produce supplied to the conventional retail grocery industry is grown on the largest, most profitable farms, the bulk of payments would still be directed to those farms, as is the case currently with the commodity support program. However, the USDA could use this opportunity to ensure that smaller-scale and regionally based growers engaged in direct marketing benefit as well, by expanding the Farmers' Market Nutrition Program, another FNS program that distributes coupons to WIC recipients and qualified seniors once-yearly on an annual federal budget of only around \$20 million (Joy et al. 2004). Food stamp recipients, and perhaps WIC recipients, might also receive a 50% discount when benefits were used to purchase qualifying products at certified farmers' markets, with reimbursements going to growers and market operators instead of wholesaler-distributors.

Dedicating other funding, perhaps through the Risk Management Agency or Agriculture Marketing Service, toward a farmers' market incentive program could increase the amount of discount offered, and provide farmers' market operators and participating growers with a level of reimbursements necessary to subsidize the develop-

ment and operation of farmers' markets in currently underserved low-income neighborhoods.

#### How incentive program would work

**Costs.** When crunching the numbers, one finds that a redirection of all 2003 farm commodity payments (nearly \$11.5 billion) to a marketplace-based incentive program would represent \$104 per month per food stamp household, or a 56% increase in the average monthly household benefit. Redirecting the 87% of farm commodity payments paid to the top 20% of farms (almost \$10 billion) would provide each food stamp household with an additional \$90 (46%) in purchasing power each month. Remember that these dollars are not being paid directly to food stamp participants as benefits, but rather to retailers, wholesaler-distributors and growers to create retail price reductions that apply to purchases made by participants. Furthermore, it is unlikely that these incentives would simply result in product substitution, because food stamp recipients — like the majority of Americans — do not currently purchase significant quantities of fruits, vegetables and whole-grain products.

**Benefits.** Many low-income Americans find healthful foods expensive and hard to find, and they need and deserve targeted assistance to help

purchase them. A typical food stamp household, with one female adult and two children ages 3 and 7, might receive roughly \$250 in benefits each month. (According to the USDA, 86% of all food stamp households contain children, and the "average" food stamp household with children had 3.3 people [compared to 2.3 people for all households] and received \$268 per month in benefits.)

The Thrifty Food Plan (TFP) is an economic model developed by the USDA Center for Nutrition Policy and Promotion to create a "market basket" of items that meet U.S. Dietary Guidelines for nutrient intakes while constraining costs; the TFP is used as the basis for food stamp allotments and assumes that all food is purchased at stores and prepared at home. According to the USDA, the monthly cost of the TFP for this family in July 2003 — containing 25.2 pounds of vegetables other than potato products and 46.48 pounds of fruit — was \$301.20 (\$51.20 after deducting food stamp benefits), of which perhaps \$100 is allocated to purchase fruits and vegetables. However, it is highly unlikely that our typical food stamp family is following the TFP and purchasing anything close to 70 pounds of fruits and vegetables each month. This is because over half of all food purchases today are consumed outside the home, and because fruits and vegetables are often much more expensive and less available in the inexpensive restaurants, small neighborhood markets, and food-service settings likely to be frequented by low-income Americans.

What would in effect be half-off sales would provide a significant incentive for food stamp recipients to purchase more nutritious foods. Although these "sales" certainly would not guarantee that all food stamp recipients meet the recommendations in the 2005 Dietary Guidelines for Americans overnight, such incentives would no doubt cause a great many recipients to start purchasing and eating more health-promoting

By reconfiguring federal commodity-support programs, the author argues that USDA could invest in the good dietary habits of low-income Americans while creating new markets for the growers of healthy foods. Currently, the vast majority of commodity subsidies go to large-scale growers of corn, soybeans, cotton, rice and, *below*, wheat.



foods such as fruits, vegetables and whole grains (USDA-HHS 2005). In fact, these incentives might go a long way toward eliminating two of the main barriers that consumers cite as keeping them from eating a better diet: cost and access. What's more, by linking incentives directly to products that have known health benefits, there is a high likelihood that these redirected subsidies would result in additional future cost savings, in the form of improved health, increased productivity, and other economic and social benefits.

With such significant potential impacts, one must ask why the USDA isn't more willing to consider making targeted cuts in the commodity support program in order to improve (but not necessarily expand, in terms of eligibility criteria or benefit levels) the FSP. Does it really make sense to support the production of products such as high-fructose corn syrup by giving corn growers direct subsidy payments, and to support the purchase of products like Coca-Cola by giving food stamp recipients benefits but no incentives to spend extra for nutrients instead of maximizing calories? Why not instead invest in the health and good dietary habits of low-income Americans, while providing marketplace support for the producers of health-promoting food products? The USDA and members of Congress would

do well to ask themselves these questions, perhaps while they're debating the 2007 Farm Bill (see page 5).

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# Central Coast consumers want more food-related information, from safety to ethics

Philip H. Howard

*Information is lacking on what consumers want to know about food production, processing, transportation and retailing. Focus groups and a random-sample mail survey of consumers in the Central Coast region indicate that food safety and nutrition generate the most interest. However, ethical concerns such as the humane treatment of animals, the environmental impacts of food production and social justice for farmworkers also have strong support. The results suggest that voluntary food labels on these issues may be a promising way to meet consumer needs for more information.*

Consumers are increasingly able to influence the way food is produced, processed, transported and sold through their purchasing decisions (Kinsey 1999). It is therefore surprising that few studies have attempted to find out what these potentially powerful consumers want to know about the food system, in order to anticipate these changes. Most consumer research related to food and agriculture is conducted by organizations with specific interests, such as the promotion of a particular commodity or type of production. Researchers typically decide what people ought to know, and then proceed to measure their knowledge (or lack of knowledge) to identify where education and marketing efforts should be targeted (James 2004). Such an approach may risk missing what the public actually wants to know — information that could help growers, processors and retailers plan for consumer-driven changes.

We asked consumers themselves what aspects of food production, processing, transportation and retailing they were most interested in knowing



In a survey of Central Coast consumers, nearly 60% reported that they find it difficult to learn about how their food is produced.

more about. Our research involved two methods: a series of five focus groups, and a random-sample mail survey of 1,000 households. A focus group is a structured roundtable discussion with a small number of people, usually 6 to 10, to elicit in-depth information (Morgan 1998). The focus group results informed many of the survey questions, and helped reveal the meaning behind the survey responses. The survey, on the other hand, quantified the level of interest in specific food-system topics. Both components were conducted in the Central Coast region of California, which we defined as San Mateo, Santa Clara, Santa Cruz, San Benito and

Monterey counties. This comprises the study area for a U.S. Department of Agriculture (USDA)–funded project exploring ways to improve the sustainability of the food and agricultural system in the region; this project supported our research.

## Measuring consumer interests

**Focus groups.** Focus group participants were recruited in person from two large supermarket chains in Seaside and Salinas, a discount grocery store in San Jose, a farmers' market in Aptos and a natural foods store in Monterey. These sites were chosen in order to ensure that a diverse group of consumers from the



"Eco-labels" have grown in popularity as a way to provide consumers with information on how food was produced. *Top, left to right*, the "California Grown" campaign identifies crops and other goods produced in-state; the Humane Society of the United States partially funds a humane-farming certification; the USDA's organic seal is the most prominent eco-label in the United States; the "Fair Trade" label certifies that growers receive a fair price for crops and workers are paid a fair wage. *Bottom*, the Community Alliance with Family Farmers' "Buy Fresh, Buy Local" campaign highlights agricultural products from four different California growing regions.

TABLE 1. Demographic characteristics of mail survey respondents compared to 2000 U.S. Census figures in five-county Central Coast region

Characteristic	Respondents	2000 Census
Non-Hispanic white	58%	46.8%
Asian	19.8%	20.1%
Hispanic	10.5%	27.1%
Women	52.3%	49.5%
Age 65 and over	17.0%	10.3%
High school diploma	96.8%	81.7%
Bachelor's degree	54.6%	36.9%
Median income (\$)	75-100K	68,193
Sample size (n)	475	3,100,344

groups were analyzed, using the software NVivo 2.0, and statements were classified into categories. Categories that were discussed in all five focus groups were included in several sections of the survey. These sections included: a list of topics defined as food-system interests (such as nutrition, environmental impacts and working conditions); a list of information sources from which respondents could choose to learn more about these interests (such as radio, the Internet and product labels); and a list of five potential standards that could be represented by voluntary food labels (such as local, small scale and humane). The survey was pre-tested in person with 20 consumers recruited at an independent grocery store in Santa Cruz to improve its clarity and reliability.

In April 2004 the survey was sent to 1,000 households in the study area, using randomly sampled names and addresses provided by the marketing firm USADATA. A modified Tailored Design Method was employed, which involved four mailings: (1) a pre-notice letter, (2) the survey with a \$1 bill incentive and stamped return envelope, (3) a follow-up postcard and (4) a replacement survey and return envelope (Dillman 2000). While this method typically also employs a second replacement survey mailing, this step was omitted due to budget constraints. The final response rate was 48.3%. The survey instructions indicated that the primary food purchaser for the household was to complete the questionnaire. Respondents' demographic characteristics were generally similar to those identified in the 2000



Surveyed consumers wanted information about their food to be available at the point of purchase. Product labels, brochures and retail displays, above, were the most-preferred options.

Central Coast region participated. To be eligible for the study, participants had to be the primary food purchaser for their household and at least 18 years old. A total of 27 people participated in these discussions in April and May 2003. Because focus group research is conducted to obtain qualitative information that cannot be obtained through survey research, a fully representative population was not expected. Seventy percent of the participants were female, largely due to the fact that women were encountered more often at the recruitment sites. Indeed, research suggests that women make 69% of food purchases in the United States (FMI 2003).

Thirty percent of participants classified themselves in ethnic groups other than non-Hispanic white.

The focus group questions included, "If you could find out anything about your food, or any of the steps involved in getting food to your plate, what would you like to know?" and "How would you prefer to get this information?" Many of the participants expressed surprise that their input was being gathered, and were thankful for the opportunity to provide their opinions.

**Survey.** Themes identified in the focus groups informed the design of the survey. Transcripts of the focus

**TABLE 2. Food-system information needs among survey respondents (n = 475)**

	Agree	Neutral/not sure	Disagree
	..... % .....		
I already know enough about how my food is grown, processed, transported and/or sold	15.8	24.4	59.8
It is difficult to find out information about how my food is grown, processed, transported and/or sold	59.0	28.4	12.6

U.S. Census, except that the number of Hispanic respondents was lower, the number of respondents age 65 and over was higher, and reported education levels were higher than would be proportionate for the region (table 1).

**Food-system concerns identified**

Only 15.8% of survey respondents felt they already knew enough about their food, while most (59.8%) felt they did not know enough (table 2). In addition, a majority of respondents (59%) agreed that it is difficult to find this information. These results point to a need for growers, processors and retailers to provide consumers with more details about their products.

Eight topics were presented to survey respondents: safety, nutrition, the treatment of animals, environmental impacts, working conditions, wages, the influence of large corporations and how far food travels. Respondents ranked them on a scale from 1 to 10, with 1 indicating no interest and 10 indicating a great amount of interest (table 3). Not surprisingly, the scores indicated that survey respondents were most interested in food safety and nutrition: nearly all respondents ranked these topics near the top of the scale. A number of previous surveys have consistently shown food safety and nutrition to be important concerns, even for people with few other food-related interests (Step toe et al. 1995; McBride 1997).

A review of the focus group results provided a more in-depth understanding of the survey results. For example, one focus group participant stated, “Who knows what the heck is in half the stuff we buy, I mean I don’t . . . Frankly, I don’t care as long as it doesn’t get me sick.” This was a minority view, however, as most focus group participants also had a number of concerns beyond their personal health. The survey results supported

this broader concern. The treatment of animals involved in food production, environmental impacts and working conditions all received mean scores of greater than 7 on a scale of 10 (table 3).

In the focus groups, the treatment of animals elicited the most emotion. Several participants had toured slaughterhouses and said this experience had a lasting effect on the way they felt about their food. Others had changed their consumption habits after learning how some animals are treated, such as veal calves. In addition, for some people the interest in animal welfare overlapped with personal health concerns. For example, a focus group participant discussing the inhumane aspects of confinement animal production asked, “Then are you eating growth hormone . . . or whatever you’re putting in them, and what does that do? In the long run, what’s that doing to you?”

On the issue of environmental impacts, focus group participants most frequently expressed concerns related to pesticides and genetic engineering. Some participants were also concerned about irradiation and the impacts of food packaging or food waste. Several participants noted that environmental impacts were much more important to them than other concerns about the food system.

For the topics of working conditions and wages, focus group participants were interested in the treatment of farmworkers, such as backbreaking labor performed for very low pay, and the exploitation of migrant workers. Workers involved in other aspects of the food system, such as processing or retail, were not discussed as frequently. When asked specifically to list criteria they would like to see improved for workers involved in the food system, participants mentioned higher wages, protection from exposure to pesticides, health



**In focus groups, the treatment of food animals elicited the most emotion.**

care, education, adequate food, limited working hours and adequate housing.

The influence of large corporations was the next-highest ranked topic, receiving a mean score of 6.6 out of 10 on the survey. This theme emerged in all of the focus groups, though it was much more strongly held by some individuals. One participant said, “The huge conglomerates that are controlling agriculture really, really bother me,” and others named specific multinational food processors and chemical companies whose motives they distrusted. Some participants blamed these corporations for the low prices that farmers receive for their products and the loss of family farms.

In the survey, how far food travels was the lowest ranked topic, with a mean score of 5.8. Participants had varying reasons for their interest in this topic, involving economic, food safety or environmental concerns. Most

**TABLE 3. Level of interest in food-system topics among survey respondents (n = 475)\***

Topic	Mean	Standard deviation
Safety	9.4	1.4
Nutrition	8.9	1.7
Treatment of animals	7.4	2.7
Environmental impacts	7.3	2.4
Working conditions	7.2	2.6
Wages	6.7	2.7
Influence of large corporations	6.6	2.9
How far food travels	5.8	3.1

\* 1 = none at all, 10 = great amount of interest.





When survey respondents were asked in paired comparisons to choose which aspect of food production that they would like to see represented by third-party-certified eco-labels, 22% picked “locally grown” while 16.5% chose a “living wage” for farmworkers, *left*, as their top-ranked choices. *Right*, a grain ship transports the commodity overseas.

wanted to know the country of origin of their food. One participant said, “I guess I’d like to know (where fruits and vegetables are from) because I’d like to know are we producing our food or are we actually reaching out into other countries?” Some participants wanted to support the U.S. economy, while others went further and expressed interest in supporting their local economies. Another stated reason for wanting to know where food came from was concern about the safety of imported food, such as the potential presence of pesticides banned in the United States or contamination with microbes that could cause human diseases. Finally, some participants wanted to know how much fossil fuel was consumed in transporting their food.

Of 60 survey respondents who identified additional food-system topics in a write-in section, 22% had reservations about genetically engineered food, and

15% wanted more information on pesticides. Other interests identified by more than one respondent were freshness, where food was grown and the fate of food waste.

#### Preferred information sources

To find out how people would prefer to obtain more information about their food, the survey presented categories suggested by focus group participants (table 4), along with instructions to choose up to four of the categories. Product labels were the most popular choice for obtaining more information about food, selected by 81.3% of survey respondents. A brochure or retail display was a close second at 76.4%. These results suggest that most consumers want information about food when they are actually making the decisions about purchases. Print media and Web-based information were selected by approximately half of respondents. A number of focus group participants also expressed an interest in labels, but also wanted more-detailed information via a Web site.

A smaller proportion of consumers surveyed (18.7%), indicated that they were interested in taking tours to see how food is produced. One focus group participant mentioned watching television shows that take viewers behind the scenes of food production, such as “Unwrapped” and “Good Eats,” which are on the cable channel “Food Network.” These are two of the highest-rated shows on this rapidly

growing channel. Similar video productions might be an ideal way to reach the 26.3% of survey respondents who chose television, videotape or DVD as the way they would prefer to get more information about their food. Talking to the seller was the least preferred option, selected by only 11.8% of survey respondents.

#### Organic and other eco-labels

A recent trend in food marketing is an increase in “eco-labels” — seals or logos signifying that the product meets certain standards, such as environmental protection or social responsibility. Currently the most prominent eco-label is organic, which in 2002 became a national standard accredited by the USDA. While organic food sales comprise less than 2% of all food sold in the United States, they have increased by at least 20% per year for the last 15 years, a trend that the industry expects to continue in the near future (Rawson 1998; OTA 2003).

Another eco-label that is rapidly growing is “Fair Trade,” which applies only to select, imported products that are certified in the United States by a nonprofit organization, TransFair USA. The fair trade standards ensure that grower cooperatives receive a minimum price, or that workers are paid a fair wage. Although its market share is much smaller than organic, sales of fair trade products such as coffee and tea increased by more than 40% in the United States from 2001 to 2002 (FTF 2003),

TABLE 4. Food-related sources of information preferred by survey respondents (n = 475)

Source	Respondents
	%
Product labels	81.3
Brochure or retail display	76.4
Newspapers/magazines/books	51.4
Web pages/Internet	46.1
TV/videotape/DVD	26.3
Tours of farms and/or processing plants	18.7
Radio	13.4
Talking to seller	11.8

and have recently expanded to include fruits, such as bananas.

Participants in the focus groups were all familiar with the organic label, but most were unfamiliar with fair trade labels. Almost everyone, even those who could define fair trade and reported purchasing fair trade products, easily confused the term with “free trade.” Free trade generally refers to treaties such as the North American Free Trade Agreement (NAFTA), which eliminates certain tariffs for imported goods but does not provide a minimum price or wage.

Focus group participants wanted information on a label to be in “plain English” and easily understood. They also emphasized that any label had to “mean what it says.” They were skeptical of claims made about their food, particularly those that were not well defined, such as “natural.” A third-party certification system, such as TransFair USA’s audits to verify that fair trade standards are met by suppliers and retailers, is one way to ensure consumer confidence in claims. However, most focus group participants were not familiar with the certification process. Education about how third-party certification works may be necessary to overcome current levels of consumer distrust in food marketers.

We asked survey respondents to evaluate five potential standards that could be represented by third-party-certified eco-labels. As with the food-

system topics and preferred sources of information, these standards were based on the themes that emerged from the focus groups. However, we did not include criteria related to safety or nutrition because making claims in these areas can be contentious given the current state of scientific knowledge (Katan and de Roos 2003), and such claims are currently regulated by the U.S. Food and Drug Administration. We also excluded environmental criteria, because most of the issues raised by focus group participants related to this topic, such as pesticides and genetic engineering, are already prohibited under the USDA organic label.

As a result, the following eco-label standards were evaluated.

- **Humane:** meat, dairy products or eggs from animals that have not been treated cruelly.
- **Living wage:** provides above-poverty wages to workers involved in producing the food.
- **Locally grown:** grown within 50 miles of the point of purchase.
- **Small scale:** supports small farms or businesses.
- **U.S. grown:** grown in the United States.

Because most focus group participants were concerned about both workers’ wages and working conditions, for simplicity we chose just one of these topics. We selected a living wage because it was discussed most frequently in the focus groups. On the other hand, we included two criteria for the distance food travels because some members of the focus groups wanted to support local food production, while others were more interested purchasing food that was not imported from other countries.

We asked respondents to imagine a product that was identical except for two of the standards, and to choose the one that they preferred (for example, locally grown *or* humane). All possible combinations were presented in a series of pairs. We learned from pretesting the survey that these decisions were difficult for most people. Many respondents said they would prefer food that represented all of these

standards. However, almost 92% of the respondents completed this section. The result was a ranking of all five standards for each respondent.

Humane was most often the top-ranked choice; it was chosen in every comparison by over 30% of respondents (fig. 1). Despite this level of interest, there are currently few options for consumers who want to support these preferences. For example, there are only three humane labels in the United States, and they apply to a small number of farms: the Animal Welfare Institute’s Humane Husbandry criteria for pigs, rabbits, sheep and ducks, used by just over 300 operations; “Free Farmed,” administered by the American Humane Association for nine operations; and “Certified Humane,” partially funded by The Humane Society of the United States, which currently certifies 34 operations.

Although interest in how far food travels was not as highly rated as other topics (table 2), locally grown was the second most preferred of the five potential eco-labels. Twenty-two percent of respondents ranked locally grown as their first choice. This may be due to the fact that people prefer local products for other attributes, such as taste and freshness (Lockeretz 1986). The nonprofit organization FoodRoutes is partnered with organizations across the United States for “Buy Local” pilot initiatives, some of which include local labels to help consumers identify these products. In California, the local partner Community Alliance with Family Farmers has a “Buy Fresh, Buy Local” campaign. A similar, statewide effort is being funded by California and the United States, along with 27 agricultural associations, for the “California Grown” label (see page 15).

Next came living wage, which was the first choice of 16.5% of respondents. Currently, consumers interested in a living wage label can seek out the “Black Eagle” label. This label identifies produce from farms that have contracts with the United Farm Workers union, which indicates “decent wages, benefits and working conditions”

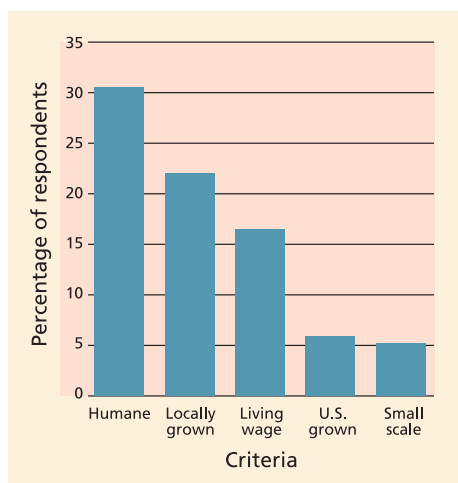


Fig. 1. Percentage of survey respondents ranking a criteria as most important (n = 436).

## Consumers who are interested in ethical aspects of the food system should recognize that their purchasing decisions can influence the way their food is grown, processed and distributed.

(UFW 2005). However, only 33 food-producing operations in the United States carry this label.

### Willingness to pay extra

An additional survey question asked respondents about their willingness to pay more for strawberries that guaranteed a living wage and safe working conditions for farmworkers. After being told the regular price was \$1.50 a pint, they were asked if they would pay 5 cents, 25 cents, 50 cents or \$1.50 more for these standards, depending upon the version of the survey (there were four versions of the survey, differing only on this one question). The median price that people were willing to pay was \$1.06, or a 71% increase over the regular price. Eighty-four percent of respondents were willing to pay 5 cents more (a 3% increase), while 67% would pay 25 cents more (a 17% increase), 56% would pay an extra 50 cents (a 33% increase), and 42% would pay \$1.50 more (a 100% increase). These results should be interpreted with caution, as surveys tend to overestimate actual willingness to pay (Donaldson et al. 1997). However, these results do indicate potential consumer interest in a domestic version of "fair trade" certified foods, particularly if the price premium is small.

The U.S. grown and small-scale labels received much less support; they were the first choice of fewer than 6% of respondents. This does not mean that respondents see these criteria as unimportant, only that they rank lower than the other criteria when people are forced to choose. U.S. grown, in particular, fared poorly in comparison with another geographic criteria, locally grown. However, a recent survey reported that 93% of U.S. consumers favored country-of-origin labeling for Canadian beef (Supermarket Guru 2003). Interestingly, the focus group participants had more trust in operations that were local, even if they were very large, which may partially explain why support for small scale ranked last among survey respondents.

### Consumers want more information

The survey results suggest that growers, processors and retailers could improve the amount of information available about how food is produced, processed, transported and sold. They should recognize food safety and nutrition as consumers' top concerns, but also devote attention to ethical issues, particularly the humane treatment of animals, environmental impacts and social justice issues. Because labels are the preferred source of information, eco-labels may be an appropriate way to address these matters.

A majority of respondents indicated a willingness to pay substantially more than the prevailing price for standards that embodied a living wage and safe working conditions. The rapid growth of organic food sales, as well as fair trade products from other countries, suggests that promoting the ethical values represented in food will continue to be a promising marketing strategy. Future research could explore the success of pilot projects described here in meeting consumer demands, as well as their potential to improve the economic viability of producers.

Consumers who are interested in ethical aspects of the food system should recognize that their purchasing decisions can influence the way their food is grown, processed and distributed. They should also recognize that this strategy of change works best for choices that are currently available, such as organic, and is far less effective for creating new alternatives. Consumers will have to express their concerns to growers, processors, retailers and policymakers if the current food system is not meeting their needs; to be taken seriously, this may require amplifying their voices by working with advocacy organizations, rather than relying solely on individual efforts.

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# Food behavior checklist effectively evaluates nutrition education

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*We developed a short food behavior checklist (FBC) to evaluate the impact of nutrition education on fruit and vegetable intake among ethnically diverse women in the Food Stamp Nutrition Education Program (FSNEP) and the Expanded Food and Nutrition Education Program (EFNEP). To validate the FBC, interviewers collected three 24-hour dietary recalls as well as responses to 11 FBC behavioral questions about fruits and vegetables from 100 English-speaking, low-income women at baseline. A randomly selected subgroup (n = 59) provided a blood sample for analysis of total serum carotenoids at baseline and follow-up. After 6 hours of nutrition education, the treatment group reported significant improvements in three of the seven FBC questions related to fruit and vegetable intake, while no significant changes occurred in the control group. All seven FBC questions were significantly correlated with total serum carotenoids. This short, culturally neutral FBC is a valid and reliable indicator of fruit and vegetable consumption. Compared with the 24-hour dietary recall, it is also less time-consuming to administer, code and analyze, with a reduced respondent burden.*

Valid and reliable evaluation tools are essential to justify federally funded nutrition-education programs, such as the Expanded Food and Nutrition Education Program (EFNEP) and



UCCE nutrition educator Lan Nguyen addresses a class at Fremont Adult School. In California two such programs, EFNEP and FSNEP, together evaluate the nutrition education received by 21,000 low-income families each year.

the Food Stamp Nutrition Education Program (FSNEP). UC Cooperative Extension specialists need dependable and consistent evaluation data to develop curriculum and staff training materials. Evaluation tools can also demonstrate the effectiveness of such programs, and can help nutrition educators tailor them to the specific needs of diverse populations. For example, if evaluation data indicates that participants are consistently practicing certain desirable food behaviors, the educator may adapt the intervention and devote more teaching time to other behaviors that need improvement. In addition, good evaluation data at the county and state levels can help program directors determine how to allocate scarce resources and leverage additional funds to enhance or expand successful programs. Data documenting the successful outcomes of the EFNEP and FSNEP programs has been useful in generating new funding for nutrition and wellness education, as well as research activities.

## EFNEP and FSNEP impact

The U.S. Department of Agriculture (USDA) funds EFNEP and FSNEP to provide community nutrition education

to families with limited incomes (up to 180% of the poverty level). EFNEP has served California families with minor children since 1969 and currently conducts adult education programs targeting head of households in 16 counties. The target group is preschool children, but families with older children are not denied services. About 10,000 families graduate (with certificates) and are evaluated annually after receiving a minimum of 6 to 8 or more hours of instruction in nutrition, money management and food safety. Also, 10 of the 16 counties have youth programs that provide nutrition education training to teachers in elementary schools with large percentages of children qualifying for free and reduced-priced meals. The FSNEP program, instituted in California in 1994, targets food stamp recipients and applicants in 42 counties, and evaluates the nutrition education received by about 11,000 families annually. Both EFNEP and FSNEP hire and train paraprofessional staff as nutrition education assistants (now called nutrition educators). EFNEP and FSNEP staff collaborate with agencies and groups to teach low-income adults how to plan, purchase and prepare low-cost foods for a nutritious diet.



EFNEP and FSNEP nutrition educators (including, above, Michele Brown) teach low-income adults how to plan, purchase and prepare economical, nutritious food. In California, a new food behavior checklist provides a simpler and more user-friendly method for evaluating the programs' effectiveness.

EFNEP and FSNEP are required by USDA to conduct pre- and post-education evaluations of all adult graduates to determine impacts on dietary practices. Both programs use the most recent Dietary Guidelines for Americans (USDA 2005) as a standard to measure improvement among their graduates. Since 1969, EFNEP has measured change in dietary intake with nutrition indicators derived from one pre- and one post-24-hour dietary recall. The participant is asked to recall and record all the food and drink they consumed during the 24-hour period just prior to the recall. If the recall is conducted one-on-one, the educator asks the person to recall the food items and the time of day or night they were eaten and then records the responses. In a group setting the educator explains how the recall is done and answers questions, and the participant records his or her own responses.

In a randomized, controlled study of more than 600 EFNEP graduates in California, the 24-hour dietary recall method evaluated the impact of 6 to 8 hours of nutrition education using the one-on-one teaching model. This study found significant improvement in fruit and vegetable ( $P < 0.001$ ) and milk consumption, food preparation, and shopping skills (Del Tredici et al. 1988). Similarly, results from annual evaluations of FSNEP graduates in California showed positive benefits for nutrition education delivered in small group settings (Joy et al. 2001).

Other states have documented that the positive impact of the EFNEP program can be long lasting (Burney and Haughton 2002; Torisky et al. 1989). A Michigan study found that the positive improvements after the EFNEP inter-

vention were maintained for more than 5 years (Nierman 1986); plus, the families saved more money on food than the federal cost of administering the EFNEP program (Burney and Haughton 2002).

### New evaluation tools needed

Over the last decade, the adult EFNEP program in California moved from a one-on-one teaching model to a group delivery method with between 6 and 30 participants in a class. Administering the traditional 24-hour dietary recall in a group setting is cumbersome. Data collected from these self-administered dietary recalls may not be complete, because an accurate recall requires specific probing by an interviewer that is not feasible in a group setting. Moreover, since underreporting is common with the dietary recall method, particularly among overweight women, use of this method may be especially problematic in low-income groups with a high prevalence of overweight and obesity (McClelland et al. 2001). With today's emphasis on group education, EFNEP teaching staff views the 24-hour dietary recall as an impediment and have stressed the need for a new evaluation tool.

An alternative to the 24-hour recall, food frequency questionnaires (FFQs), are also difficult and time-consuming to administer in a group (Kristal et al. 1998). FFQs include a list of 100 or more foods, a rough indication of portion size, and a set of frequency options (how often consumed) to choose from. Although brief FFQs are available (15 to 60 questions) these shortened versions may not contain enough food items or details to be useful among the ethnically diverse populations served in California (McClelland et al. 2001). With longer

evaluation tools such as the full FFQ, respondent burden is also a major concern among low-literacy populations. Moreover, neither the dietary recall nor the FFQ assesses behavioral changes in food-related practices such as reading nutrition labels, removing skin from chicken, serving vegetables at dinner, eating fruits and vegetables for snacks, managing money or handling food safely. However, these are key behaviors targeted by EFNEP and FSNEP.

We recognized the need for a simple and less time-consuming evaluation tool. At USDA's request, we began a study in 1997 to validate a food behavior checklist (FBC). We developed the

### GLOSSARY

**Convergent validity:** Agreement between two instruments or indicators measuring the same construct (i.e., food behavior checklist and 24-hour dietary recall).

**Criterion validity:** Agreement between an instrument or indicator and another measure considered to be a "gold standard," which tap into the same construct (i.e., the food behavior checklist and a biochemical indicator).

**Internal consistency:** An alternative estimate of reliability, which measures agreement among the questions on the fruit and vegetable FBC.

**Readability:** Ease of understanding or comprehension due to vocabulary, sentence length, writing style and other factors on the FBC.

**Reliability:** Measures the stability of individual questions on the FBC over time and uses a scale to measure the agreement between similar questions.

**Sensitivity to change:** Ability of the FBC to detect changes in fruit and vegetable behaviors occurring as a result of the intervention.

## The food behavior checklist is more user-friendly and less cumbersome than the traditional 24-hour dietary recall.

California FBC and tested it for validity and reliability to measure dietary quality related to chronic disease. Eleven of the 41 FBC questions were related to fruit and vegetable consumption. Our study focuses on whether the new FBC may be used as an alternative to the 24-hour food recall to assess fruit and vegetable intake among EFNEP and FSNEP participants.

### Evaluation tool criteria

In addition to being valid and reliable, a good evaluation tool should be responsive to change, easy to administer and analyze, and culturally relevant with a low respondent burden (see box, page 21). A tool is considered valid or accurate if it yields an estimate that correlates well with an accepted “gold standard” (criterion validity). The validity of a new tool may also be established by comparing it to a known tool that measures a similar concept or behavior (convergent validity). A tool that is lengthy or difficult to administer could detract from the delivery of nutrition education, as well as limit the accuracy of the evaluation data.

A reliable evaluation tool must yield similar results consistently when it is administered to the same people on at least two separate occasions in the absence of an intervention. Another test of reliability, referred to as internal consistency, is a measure of correlations among a group of related questions (within the same tool) on the same scale.

A good tool should also be sensitive enough to detect changes in client behaviors exhibited after completing the educational program. The limited-literacy and culturally diverse groups in the EFNEP and FSNEP programs are other key considerations, particularly if the evaluation tool is self-administered in a group setting.

### Developing the checklist

A detailed description of the research methods and findings related to developing the comprehensive FBC appears in earlier publications (Murphy et al. 2001; Townsend et al. 2003). This paper gives an overview of the steps taken to develop a short fruit and vegetable FBC,

then test it with a group of low-income women in FSNEP.

### Fruit and vegetable questions.

The questions included in the fruit and vegetable FBC were based on the subject matter taught in the EFNEP and FSNEP programs and the desired behavior changes to be evaluated (see box, this page).

**Validation.** Baseline data from the original 1997 study of low-income women (n = 100) receiving 6 hours of nutrition education was used to validate the fruit and vegetable FBC questions (Townsend et al. 2003).

We used three validation methods. First, we correlated fruit and vegetable questions with a biomarker, total serum carotenoids (criterion validity). Carotenoids found mainly in fruits and vegetables are the chief source of vitamin A in North American and European diets. These fat-soluble compounds can be stored and converted to vitamin A inside the body (Kagan 1953). They are absorbed in the small intestine, enter the blood via the lymph system and reach peak concentration in the blood within 3 to 5 hours of ingestion. The concentration of human serum (blood) carotenoids depends largely upon the content of the carotenoids in the diet (Wohl and Goodhart 1968).

Second, we compared fruit and vegetable intakes, as determined by the FBC and three 24-hour dietary recalls (convergent validity). Finally, we compared nutrient intakes such as vitamins A, C and folate (part of the vitamin B complex), as determined by the FBC and the three dietary recalls (convergent validity).

### Applying reliability, other criteria.

Cronbach’s alpha test was used to determine if the results were internally consistent or reliable (Nunnally and Bernstein 1994). As another means to measure reliability, the FBC questions were administered to a separate group of 44 low-income women on two different occasions 3 weeks apart, with no nutrition education in between. The fruit and vegetable FBC was also evaluated for clarity, literacy level and appropriateness for diverse

### Food behavior checklist: Questions related to fruit and vegetable intake

- 1. Do you eat more than one kind of fruit daily?**
  - Do not eat fruit
  - Usually or always
  - Often
  - Sometimes
  - Rarely or never
- 2. During the past week did you have citrus fruit or citrus juice?**
  - Yes
  - No
- 3. Do you eat more than one kind of vegetable a day?**
  - Do not eat vegetables
  - Usually or always
  - Often
  - Sometimes
  - Rarely or never
- 4. How many servings of vegetables do you eat each day?**
- 5. Do you eat two or more servings of vegetables at your main meal?**
  - Usually or always
  - Often
  - Sometimes
  - Rarely or never
- 6. Do you eat fruit or vegetables as snacks?**
  - Usually or always
  - Often
  - Sometimes
  - Rarely or never
- 7. How many servings of fruit do you eat each day?**

All items were positively correlated to both serum carotenoids and dietary recall variables.

audiences (non-Latino white, non-Latino black and English-speaking Latino adults).

### Randomized, controlled FBC trial.

Performance of the short fruit and vegetable FBC was assessed among FSNEP participants in eight California counties: Alameda, Fresno, Los Angeles, Monterey, San Francisco, San Joaquin, San Mateo and Santa Clara. FSNEP staff recruited participants from schools and other community organizations.

At baseline, trained interviewers collected demographic data, three 24-hour dietary recalls and the FBC from 100 English-speaking, low-income women who were eligible for food stamps and had at least one child less than 19 years old living at home. These women were randomly assigned to the intervention group that received 6 hours of FSNEP classes or to a delayed control group



In this study, a seven-item portion of the food behavior checklist was validated as a reliable measure of changes in fruit and vegetable consumption. Alternative versions for non-English-speaking and low-literacy audiences are now being evaluated. *Top*, UCCE nutrition educator Nelly Camacho administers the checklist to program participants in Hayward.

that received the classes after the study was completed. The content of the nutrition education classes included the Food Guide Pyramid, food labeling, unit pricing, food selection, meal planning, food-related money management and shopping. (The USDA Food Guide was significantly revised in mid-2005, several years after our study, to stress variety rather than just promoting the consumption of five half-cup servings of fruits and vegetables per day.)

The intervention and control groups were not statistically different for a number of variables: education, monthly income, household size, race/ethnicity and participation in food assistance programs. However, the women in the intervention group were older than those in the control group,  $33.2 \pm 8.2$  years versus  $25.8 \pm 4.5$  years ( $P < 0.0001$ ) (table 1).

Complete follow-up data, including three additional 24-hour dietary recalls and a second fruit and vegetable FBC, was gathered for 73 women in the intervention group and 14 women in the control group. A randomly selected intervention subgroup ( $n = 59$ ) provided a second blood sample for

analysis of total serum carotenoids at completion of the educational experience.

### FBC versus dietary recall

Paraprofessional staff reported that the fruit and vegetable FBC was easier to administer and required less time than the 24-hour dietary recall. The short FBC initially contained 11 questions related to fruit and vegetable intake. Of these, seven questions were significantly and positively related to both serum carotenoid levels (the "gold standard") and dietary recall variables (see box, page 22) (Murphy et al. 2001). Questions related to serum carotenoid levels included: Do you eat more than one kind of fruit daily? and Do you eat more than one kind of vegetable a day?

These seven questions were significantly correlated with two or more nutrient or food group intakes (such as vitamins A and C) as estimated by the dietary recall method. The dietary recalls were analyzed using the USDA Nutrient Database for Individual Surveys (USDA/Food Survey Research Group, 1995 release, updated to Release 8). Daily servings of fruits and vegetables as-

TABLE 1. Study sample (intervention  $n = 73$ , control  $n = 14$ ) at baseline

Demographic	Control <i>mean ± SD</i>	Intervention <i>mean ± SD</i>
Age (years)*	25.8 ± 4.5	33.2 ± 8.2
Education (years)	11.6 ± 0.8	12.1 ± 1.7
Household size (no.)	4.1 ± 1.6	3.9 ± 1.2
Ethnicity/race†	Control	Intervention
	<i>no. (%)</i>	<i>no. (%)</i>
White	3 (21)	19 (26)
Black	7 (50)	31 (42)
Latino	2 (14)	15 (21)
Other	2 (14)	8 (11)
Participation in assistance programs	Control	Intervention
	<i>no. (%)</i>	<i>no. (%)</i>
WIC‡	6 (43)	32 (44)
Food stamps	14 (100)	65 (89)
Child nutrition programs	3 (21)	29 (40)
Monthly income†	Control	Intervention
	<i>no. (%)</i>	<i>no. (%)</i>
≤ \$500	1 (7)	12 (16)
\$501–1,000	8 (57)	46 (63)
\$1,001–1,500	4 (29)	7 (10)
\$1,501–2,000	1 (7)	5 (7)
≥ \$2,001	0	3 (4)

\* Significant at  $P < 0.0001$ ; all other comparisons not significant.

† Not significant by chi-square.

‡ WIC = Women, Infants and Children.

essed by the 24-hour dietary recalls were correlated to total serum carotenoids ( $r = + 0.35$ ,  $P < 0.01$ ). However, a fruit and vegetable score based on the sum of responses for the seven FBC questions had a higher correlation with serum carotenoids ( $r = + 0.44$ ,  $P < 0.001$ ) (Townsend et al. 2003).

The internal consistency of these seven fruit and vegetable questions was also acceptable based on the Cronbach alpha of 0.80. Reliability coefficients for the seven individual questions ranged from 0.35 ( $P < 0.05$ ) to 0.65 ( $P < 0.0001$ ). No ethnic or cultural differences were found among the responses to these questions at baseline (Townsend et al. 2003).

### Fruit and vegetable intakes

Once the validity of the fruit and vegetable FBC was established, we used it with a group of low-income women participating in nutrition education programs. Before the education experience, most of these women did not meet the Food Guide Pyramid recommendations. Only 27% consumed at least two serv-

ings of fruit and about 37% consumed three or more servings of vegetables a day. The fruit and vegetable consumption patterns of these low-income women (a mean of 4.5 servings per day) were very similar to the general U.S. population (4.4 servings, median) (Thompson et al. 2005). These fruit and vegetable figures may seem high, but note that all forms of potatoes — including french fries — were counted as vegetables. In addition, 95% of the women studied consumed less than the recommended 25 grams of fiber per day (Institute of Medicine 2002). Their fat intakes ranged from 29% to 42% of total calories, compared with the recommended range of 25% to 35%.

From baseline to follow-up, the intervention group reported significant improvements in the three fruit questions on the FBC (Townsend et al. 2003). The control group did not report any significant changes for fruits and vegetables (data not shown). However, no significant changes occurred for either group in the number of daily servings of fruits and vegetables, as estimated by the dietary recall method. Since the biochemical indicator (serum carotenoids) tended to increase over time (intervention: + 5.2  $\mu\text{g}/\text{dl}$ ; controls: + 4.1  $\mu\text{g}/\text{dl}$ ), the dietary recall method, as administered in this setting, may not have been as sensitive to change as the FBC.

For both the intervention and control groups, the energy intake determined by the dietary recall method was actually lower at follow-up, compared to baseline (intervention: -217 kcal; controls: -456 kcal). This drop over time may have been due to subject fatigue in providing multiple dietary recalls.

Due to limited funds, the number of women remaining throughout the study in the control group was quite small ( $n = 14$ ), which probably limited the study's power to detect change in fruit or vegetable intakes assessed by the FBC or dietary recall. Use of the valid FBC in an intervention study needs to be replicated with a larger sample. This endeavor will be relatively easy now that the FBC's validity and reliability have been established, and since it is no longer necessary to collect blood serum samples and multiple 24-hour dietary recalls.

### Checklist advantages

Based on the correlations with total serum carotenoids, the fruit and vegetable FBC appears to be valid and reliable for the assessment of fruit and vegetable intake. In addition, we found that the fruit and vegetable FBC has a number of advantages over the group-administered dietary recall for evaluating the impact of nutrition education. Overall, the FBC is more user-friendly and less cumbersome for both the clients and nutrition educators. The entire FBC takes less time to administer (10 minutes vs. about 30 minutes), and is less complex and easier to score than the dietary recall. The FBC was simple enough to be self-administered with minimal difficulties.

The FBC questions were reflective of the subject matter taught in EFNEP and FSNEP, and the results were responsive to the program goals and outcome objectives. Preliminary results indicate that the seven-item fruit and vegetable FBC is culturally and ethnically neutral with no differences detected in response patterns among English-speaking white, Latino and black women.

EFNEP and FSNEP would benefit from additional research to determine if the FBC is also a valid and reliable tool for non-English-speaking audiences. Research is currently under way to determine if pictorial versions of the FBC would be useful in evaluating nutrition education impact among limited-English and low-literacy populations.

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# Smaller loads reduce risk of back injuries during wine grape harvest

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*Hand-harvest work in wine grape vineyards is physically demanding and exposes workers to a variety of ergonomics risk factors. Analysis of these exposures together with data on reported work-related injuries points to the risk of back injury as a prevention priority, in particular the lifting and carrying of tubs of cut grapes (weighing up to 80 pounds) during harvest. Our study evaluated the effectiveness of an intervention — the use of a smaller picking tub — on the incidence of musculoskeletal symptoms among workers during two harvest seasons. Reducing the weight of the picking tub by about one-fifth to below 50 pounds resulted in a five-fold reduction in workers' post-season musculoskeletal symptom scores, without significant reductions in productivity.*

Back injuries are the most common and costly of work-related injuries in agriculture. This is also true of other industries: overall, back injuries are the most frequently cited cause of disability in persons aged 45 or younger, and they account for the most lost time from work as well as a significant proportion of workers' compensation costs (Andersson 1981; Clemmer et al. 1991; Webster and Snook 1990; Glisan 1993; Hashemi et al. 1997).

Total costs for a first-time back injury can reach \$10,000, with costs for repeated back injuries reaching as much as \$300,000 (OSU Research News 2001; NRC-IOM 2001). With an average of 3,350 back injuries reported each year



**In wine grape vineyards, harvest workers suffer from a high rate of musculoskeletal disorders. Switching to a smaller picking tub can reduce the level of reported symptoms without significantly affecting productivity.**

in California agriculture (AgSafe 1992), a conservative annual cost estimate for back injuries is more than \$30 million.

The causes of occupational back injury are well understood. Literature reviews indicate that heavy physical work, repeated lifting and twisting are consistently associated with greater risk. Generally, those with the heaviest labor duties have the largest numbers of injuries (including to the lower back), and lifting causes more than half of back injuries reported.

Marras et al. (1993, 1995) developed a dynamic methodology for identifying specific factors associated with known job tasks, using a spinal movement feedback monitor (Lumbar Motion Monitor). Marras identified five risk factors involved in manual lifting that predicted increased risk of injury in both medium- and high-risk jobs: lifting frequency, load moment (weight of the object times its distance from the lower back), trunk lateral velocity, trunk twisting velocity and sagittal (or forward-bending) angle.

More problematic is the issue of preventing workplace back injuries. Despite the considerable research in this area, Leamon (1994) points out that there is a paucity of research on the practical application of major theoretical models of causation to risk reduction. Most prevention continues to emphasize worker training. However,

interventions aimed at reducing injury through changing worker behavior have generally failed to show any statistically significant effect on the incidence of back injuries. Contrary to general belief and industry practice, training is regarded by safety professionals as the least effective way to reduce injuries. By contrast, interventions featuring engineering controls to eliminate or reduce hazards themselves have been shown to be effective (Echard et al. 1987).

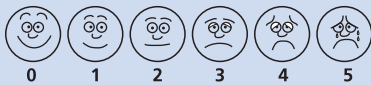
## Ergonomics in agriculture

Since 1994, the UC Agricultural Ergonomics Research Center (UC AERC) has conducted a program of ergonomics research and intervention in agricultural workplaces, with a special focus on preventing back injuries. The focus of these projects has been to identify ergonomics risk factors associated with injury, and then to design and demonstrate low-cost engineering interventions to modify tools or tasks within existing production practices. Early UC AERC projects focused on plant nurseries and wine grape vineyards, in which researchers found evidence of extremely high rates of musculoskeletal disorders (MSDs): 40 per 1,000 workers (4%) in nurseries and floriculture, and 80 per 1,000 workers (8%) in vineyard operations (Meyers et al. 2001) (for a complete definition of MSDs see box, page 26). These are reported injuries only, and are well above the rates tar-

## GLOSSARY

**Ergonomics:** The science of work, which can refer to: removing barriers to quality, productivity and human performance by fitting products, tasks and environments to people; fitting the task or tool to the person; planning work so that it fits the body's physiological efficiencies; and optimizing worker well-being and productivity.

**Health and symptom survey:** Focuses on worker reports of types and degrees of musculoskeletal symptoms in different parts of the body. Given in Spanish by trained interviewers, the survey uses visuals to help overcome cross-cultural misunderstandings. Workers circle areas on a body diagram to indicate where they experience pain and other symptoms. The intensity of pain is characterized by use of the FACES scale:



### Lumbar Motion Monitor

**(LMM):** Used to gather functional objective and quantitative measurements of the lumbar range of motion, velocity and acceleration in the work environment. The LMM consists of an exoskeleton that straps to a worker's back and has potentiometers for measurements in three dimensions: (1) range of motion of the worker's back, in terms of side-to-side, twisting and back-and-forth movements; (2) velocity, the worker's speed; and (3) acceleration, the worker's speed divided by time.

### Musculoskeletal disorder

**(MSD):** May affect muscles, tendons, joints, nerves and related soft tissues anywhere in the body. Because repeated exposure to force at the same muscle, tendon or region may result in trauma, injury and inflammation, names such as cumulative trauma disorder, repetitive motion injury and repetition strain injury have been applied to these disorders.

Diagnoses most commonly associated with MSDs include: tendonitis or inflammation of a tendon; bursitis or inflammation of the sack surrounding a joint; nerve entrapments such as carpal tunnel syndrome (which pinches the median nerve at the wrist) or cubital tunnel syndrome (which pinches the ulnar nerve at the elbow); myalgia or muscle pain, also referred to as muscle strain, tension neck, or neck and shoulder syndrome.

geted by the U.S. Public Health Service (1991), in Healthy People 2000, of an incidence of no more than 60 MSDs per 100,000 workers (0.06%).

Injury records for 194 permanent vineyard workers were reviewed for evidence of MSD incidence; these records spanned 2-1/2 years for two employers and 1-1/2 years for another. This preliminary study showed the presence of serious risk exposures for a variety of MSDs. Twenty-nine MSDs were defined for 28 (14%) of the workers studied, representing 435 lost work-days. Back injuries comprised most (69%) of the MSDs, with lifting during wine grape harvest cited as a predominate cause (Meyers et al. 2001).

### Hand-harvesting wine grapes

Hand-harvest work is the most physically demanding and intense period during the annual wine-grape crop cycle. Workers move rapidly down a vine row, reaching to grasp grape clusters and cutting them free with a small curved knife. Grapes are dropped into plastic tubs that are moved along with sideways leg thrusts. When the tub is filled the worker lifts and carries it to the gondola (usually on the other side of the picking row), then lifts the tub over his head, leans his body against the vine, and dumps the grapes over the top of that vine into the gondola on the other side. The worker then walks or runs back to his place on the row. Workers make 25 to 50 cuts per minute when picking, and tub weights of up to 80 pounds have been recorded in the field. The job also requires constant forward leaning of the upper torso while locating and cutting grapes. The working heart rate for this job was measured at 119 beats per minute (BPM), which is 70% higher than a normal resting heart rate of 70 BPM for a healthy young adult. This heart rate is in the range of that for aerobic exercise and is maintained for 6- to 12-hour shifts (except for breaks).

All of these ergonomics risk factors offer opportunities to improve physical efficiencies and reduce strains on the body. However, the repeated heavy lifting and carrying of the filled tubs has been noted as a significant factor in

back-injury risk by ergonomists, workers and supervisors, and employer injury records. Focusing on lifting and carrying the tubs also offered an opportunity to test the theoretical suggestion that loads should be reduced to less than 55 pounds, over which destructive effects on the spine become disproportionately dangerous (Davis and Marras 2000).

### Lightening the load

At first glance, it seems obvious that lightening loads that are lifted or carried would reduce back-injury risk, and research supports this approach. However, the problem is more complicated in that workers handle heavier loads differently than lighter loads. Compared to heavier loads, lighter loads may be moved with more bending, velocity and twisting. Additionally, load management is only one part of this complex job task. In changing the way they manage the load, workers become more exposed to other risk factors (for example, more time cutting in a stooped posture) and experience less rest and recovery time.

Finally, recent theoretical and research evidence suggests that there is a spinal loading threshold that may have disproportionate effects on the human spine. Davis and Marras (2000) conducted research on 15 college-age males handling loads of differing weights ranging from 20 to 92 pounds. They found that small increases in load weight (6 to 20 pounds) across the range were offset by altered body mechanics (differences in load handling) and yielded little difference in spinal loading (forces acting on the spine). Instead, they found that load weights fell into two distinct groupings: those below and those above 55 pounds. Loads at or exceeding 55 pounds were found to cause significantly more spinal loading and physical stress. In their words, "there appeared to be a weight threshold at 25 kilograms [55 pounds] at which spinal loads became increasingly risky."

Because of this trial's small number of subjects, it is too early to be certain that this proposed threshold applies to the general population. However, the concept of a weight threshold is a new way of thinking about load reduction

and its effects. Given that farmworkers must routinely lift and carry significant loads, the approach deserved testing in an agricultural setting, especially if lightening a load across this threshold might involve increasing exposure to other risk factors. Because the Davis and Marras (2000) work was preliminary, for our research we decided to use a 50-pound weight target. This provided us with a 5-pound safety margin for fieldwork, to be responsible regarding subject safety; given our results, we stand by the 50-pound target figure for field (as opposed to laboratory) applications.

### Smaller picking tub

Rather than attempting to train workers to load fewer grapes per tub, the engineering intervention we proposed consisted of using smaller plastic tubs for holding and carrying cut grapes during hand-harvest. Several intervention tubs were subjected to an informal field trial with workers in Napa and Sonoma counties during the 1997 harvest to gain worker input to the tub evaluation. A satisfactory, commercially available tub was found, which is 2 inches narrower front to back and 1 inch narrower side to side than the standard tub currently used in California vineyards. Both tubs are 8 inches high, and the external dimensions are 24 inches by 14 inches for the intervention tub and 25 inches by 16 inches for the standard tub (see page 29).

The intervention tubs were 13% smaller in volume than the standard tubs, resulting in a seasonal average reduction in load weight of 11 pounds (from 57 to 46 pounds) for the tub and its contents. While this is a relatively small weight decrease, it brought average loads below the 50-pound threshold. However, because the intervention tub was smaller, workers would have to make more lifts and carries during each shift to maintain their productivity, as measured in tons of grapes. The intervention tub filled in slightly less time than the standard tub: an average of 2 minutes 46 seconds versus 3 minutes 12 seconds. This means that lifting frequency was slightly greater for the intervention tub than for the standard tub: 21.68 lifts per hour versus 18.75 lifts per



**Grape-harvest workers typically dump their full tubs into the gondola 18.75 times per hour; the smaller intervention tub is lighter but must be lifted about 21.68 times per hour. While workers in this study delivered about 168 pounds less grapes per 8-hour shift with the smaller tub, neither they nor their bosses perceived a productivity decline because the reduction was small (only 2.5%).**

hour. Therefore, lifting repetition would be increased as a trade-off for lowering the weight per lift.

Furthermore, because it is narrower front to back, the intervention tub is carried closer to the body, bringing the load's center of gravity closer to the body. It also has a smooth bottom (as opposed to some standard tubs that are bifurcated with two ribs), making it easier for workers to slide the tub across the ground with their legs while moving along the vine row. This sliding is done three to five times per tub load (depending on the grape variety), and places high shear forces (forces that are applied in the right-to-left or forward-to-backward direction within the body) on the back and knee. The intervention tub requires about two-thirds as much sliding force as the standard tub (13 pounds vs. 19 pounds on level ground).

### Intervention trial design

The intervention evaluation was designed as a pre- and post-trial with each worker serving as his or her own control. More than 200 harvest workers from three wineries and one vineyard-management company in Napa and Sonoma counties participated in the intervention trials. Harvest trials consisted of one season using the larger standard tub (1997) and two seasons using the smaller intervention tub exclusively (1998 and 1999).

Preliminary results from the 1998 intervention-tub trial, when compared

with the 1997 standard-tub trial, suggested that the decrease in tub size was having a significant positive effect. However, there was concern that the total crop was significantly lighter in 1998 due to the El Niño weather phenomenon, which may have meant that workers were not taxed as hard as they were in 1997, a heavy crop year. To ensure the validity of trial results, we undertook a second trial using the intervention tub during the 1999 season. For the biomechanical and postural analysis, we applied two standardized instruments, the Lumbar Motion Monitor (LMM) (Marras et al. 1993) and the revised NIOSH Lifting Equation (Waters et al. 1994), to the harvest-tub lifting and carrying task.

### Lumbar Motion Monitor (LMM).

It is often difficult to apply research instrumentation in a working environment. For example, the LMM consists of an exoskeleton worn by the subject (see box page 26, photo page 29). Neither workers nor their supervisors wanted work inhibited during the important harvest period, when workers are paid on a piece-rate basis. Therefore, LMM measurements were conducted in a simulation of a working vineyard. Weighted bags were attached to vine cordons to substitute for grape clusters. To simulate grape harvesting, 10 experienced workers wearing the LMM exoskeleton filled picking tubs with the bags, lifted and carried the tubs, and dumped the contents into a container

placed at the same height as field gondolas. Lift frequency was standardized for all workers. By making the simulation match real field conditions, workers wearing the LMM performed the same movements at the same pace as workers observed during harvest.

The LMM is essentially a triaxial electrogoniometer that quantitatively describes the movement of the subject's trunk in three dimensions as the task is performed. The LMM acts as an exoskeleton of the spine, which continuously tracks position (degrees of motion) and velocity and acceleration (degrees of motion per second). This instrument was primarily used in this study to supplement the description of hand-harvest task ergonomics. Associated with LMM data is a model based on 5 years of research with workers at Ohio State University, which has been shown to predict whether a lifting job is likely to result in a high back-injury rate (OSU Research News 2001). This model reports predicted injury likelihood as percentage probability and is also now accepted in the field as a standardized instrument (Marras et al. 2000).

**NIOSH Lifting Equation.** The NIOSH Lifting Equation (Waters et al. 1993, 1994) uses quantitative data describing the human performance of a lifting task to calculate a recommended weight limit for that task. The recommended weight limit is defined as the load weight that most healthy workers could sustain for a period of up to 8 hours without increased risk of lower-back pain. The real load weight is then divided by the recommended weight limit to produce a lifting index (LI) for the tub-lifting task that describes the physical stress experienced by workers. We used this equation to calculate LI figures for the task using both the standard and intervention tubs. An LI of 1.0 is considered normal; results below 1.0 are positive while those above are negative in terms of worker health outcome (an LI greater than 1.0 poses an increased risk for lifting-related lower-back pain and injury for some fraction of the workforce). The NIOSH Lifting Equation is also recognized in the field as a standardized instrument.

**Health effects analysis**

There are several reasons why it is difficult to assess occupational MSDs

related to ergonomics intervention in agricultural settings. First, work-related MSDs can take months or years to develop, making it unlikely that reportable or diagnosable injuries would be reported during the study period. Moreover, it is unlikely that employer health records provide an accurate picture of MSD incidence among agricultural workers due to a class-based and cultural propensity to disregard physical discomfort. In addition, workers in discomfort often utilize self or home remedies rather than seeking help from organized community health-care systems.

**Symptom survey.** To enhance our power to test differences in musculoskeletal outcomes, we employed a musculoskeletal symptom survey developed and used in prior NIOSH-funded studies (see box, page 26) (Faucett et al. 2001). The survey was designed to be compatible with the cultural, linguistic and educational characteristics of Mexican field workers in California agriculture. The survey is delivered in English or Spanish by interview; uses previously tested measures of pain severity, location and duration; and includes items to assist with determining the work-relatedness of the symptoms.

The Spanish translation of the survey underwent extensive forward and backward translation with focus groups of California farmworkers to ensure the appropriateness of the vocabulary and syntax. As with any self-reported survey method, there is potential for subjective bias on the part of the respondent and the interviewer. Still, this approach has

demonstrated sensitivity in its potential for capturing changes in MSD symptom development and characterization.

Workers were given symptom surveys at the beginning and end of each harvest period (approximately 8 to 10 weeks in length), and the change in symptoms was computed for each harvest. From fall 1997 to fall 1999, 263 workers participated in this part of the study. In fall 1997, 195 workers completed both the pre- and postharvest surveys. In 1998, we were able to complete pre- and postharvest interviews with 116 workers who had participated in fall 1997. In fall 1999, we were able to reinterview 66 workers who had participated in both the 1997 and 1998 harvest-season interviews. Complete data was available for 115 workers at the end of 1998 and 64 workers at the end of 1999 (including pre- and postharvest data for each preceding year). Workers who completed all interviews did not differ statistically from those who only completed the initial survey interviews in 1997, in terms of their demographics (age, years in the United States, years worked in vineyards and years worked in California vineyards).

**Productivity analysis.** Productivity impact was assessed by monitoring the tons of grapes picked by participating crews on a daily basis. Tons picked and delivered to the winery is a figure regularly measured by all cooperators.

**Intervention vs. standard tubs**

**Ergonomics.** Our ergonomics assessment of intervention-tub use showed large reductions in targeted risk-factor exposures. Weight was reduced 19%,

**TABLE 1. Frequency of reported musculoskeletal symptoms among vineyard workers in Napa and Sonoma counties (n = 116)**

Symptom	1997		1998	
	Preharvest	Postharvest	Preharvest	Postharvest
	..... % (n) .....			
Musculoskeletal	18 (21)	70 (81)	22 (26)	33 (38)
Aching	13 (15)	68 (79)	19 (22)	32 (37)
<b>Body location</b>				
Hand	1 (1)	0 (0)	2 (2)	2 (2)
Forearm	1 (1)	3 (3)	2 (2)	3 (3)
Elbow/upper arm	2 (2)	4 (5)	1 (1)	4 (5)
Neck/shoulders	6 (7)	16 (18)	5 (6)	11 (13)
Back	7 (8)	46 (53)	13 (15)	23 (27)
Knee	2 (2)	21 (24)	5 (6)	10 (12)
Feet	2 (2)	5 (6)	1 (1)	4 (5)



**Top**, the authors fitted workers with an exoskeleton called a Lumbar Motion Monitor to study their movements during a simulated hand-harvest of grapes. **Middle**, the intervention tub (left) and standard tub (right). Note the smooth bottom and added handles on the intervention tub. **Bottom**, the intervention tub holds an average of 11 pounds less grapes than the standard tub.

## These results point to a significant opportunity to reduce the risk of back injury in all jobs that require repeated lifting of heavy loads by reducing load weights to 50 pounds or less.

from 57 pounds on average for the standard tub to 46 pounds for the intervention tub. Sliding force was reduced 32%, from 19 to 22 pounds for the standard tub, and 13 to 16 pounds for the intervention tub. Application of the NIOSH Lifting Equation yielded an LI reduction of one full point (from 3.4 to 2.4), indicating decreased risk of injury. This was echoed by the 4% to 5% decrease for the LMM-associated calculation for back-injury probability (from 0.64 to 0.60).

**MSD symptoms.** As expected, there was no significant reduction in the incidence of reported or diagnosed MSDs during the study period. In contrast, symptom reporting was relatively frequent, with aching by far the most common MSD symptom reported by workers (tables 1 and 2).

Of 95 workers who began the 1997 standard-tub harvest with no MSD symptoms, 66 (70%) reported symptoms postharvest. In contrast, of 90 workers who began the 1998 intervention-tub harvest with no symptoms, only 26 (29%) reported symptoms postharvest. Detailed statistical analysis comparing the 1997 standard-tub trial and the 1998 intervention-tub trial showed that the latter resulted in significant improvements in symptom scores ( $t = 6.310$ ,  $P < 0.001$ ). The frequency of symptom reporting for the back and knee areas, body regions affected by a significant application of force related to lifting tubs full of grapes, showed reductions in the

1998 postharvest period of 50% (table 1).

Because the harvest was lighter in 1998 than in 1997, MSD symptom data for the intervention tub was collected in 1999, when the harvest volume was more normal. A comparison of symptom scores between the 1997 standard-tub-trial baseline year (70% increase) and 1999 intervention-tub trial (46% increase) again demonstrated significant improvements with use of the intervention tub ( $t = 3.127$ ,  $P < 0.002$ ). These findings demonstrate that many workers experience work-related MSD symptoms during the wine-grape harvest period and that these symptoms grow worse over the course of the harvest. Both the onset and exacerbation of these work-related symptoms were reduced with the introduction of the intervention tub.

**Productivity.** Use of the smaller intervention tub resulted in slightly decreased productivity, as measured in pounds delivered to the gondola per shift. There was a mean reduction in grapes delivered to the gondola of 168 pounds per 8-hour work shift (average shift total of about 7,000 pounds per worker before intervention). During the field trials, neither workers nor owner/operators perceived any productivity difference. This is likely because the decrease was small (2.5%). Also, field time is not the highest concern to workers or management since payment is for tons delivered, not hours worked.

Because the intervention tub can hold an average of 11 pounds less grapes, it fills faster than the standard tub and workers make about three more trips to the gondola per hour to achieve the same productivity. However, even though workers made more trips per shift, their energy expenditure (as estimated from heart-rate changes; Garg et al. 1978) and MSD symptoms decreased over those recorded for standard-tub use.

### High risks to workers

Because MSDs are chronic, it would be overly optimistic to expect large reductions in their reported incidence over the 8- to 10-week harvest period. For that

**TABLE 2.** Characteristics of aching pain for vineyard workers in Napa and Sonoma counties who reported musculoskeletal symptoms (n = 116)

	1997		1998	
	Preharvest	Postharvest	Preharvest	Postharvest
	..... mean/median (sd) .....			
Symptom severity (1–5)	1.5/2.0 (1.3)	2.8/3.0 (0.8)	2.5/3.0 (1.3)	3.0/3.0 (0.8)
Body locations affected (possible = 33)	1.6/1.0 (1.6)	2.5/2.0 (1.6)	2.1/2.0 (1.4)	3.2/2.0 (3.0)
Symptomatic days out of last 30	8.9/3.0 (11.2)	16.2/15.0 (5.5)	13.6/15.0 (10.9)	17.1/15.0 (8.4)
Symptomatic days out of last 7	3.4/3.0 (3.5)	3.1/3.0 (2.7)	4.2/4.0 (3.3)	3.3/3.0 (2.8)
Composite symptom severity score	66.0/30.0 (99.0)	129.8/90.0 (122.2)	37.7/0.0 (105.4)	66.2/0.0 (165.9)

reason, we relied on our original approach to assessing MSD symptoms — an individual survey administered in Spanish by trained interviewers.

The MSD symptom measure is particularly relevant for this group of Hispanic workers, who do not generally recognize early discomfort as symptoms of a disorder and potential impairment, and are reluctant to report injuries. Many of the workers who did not report symptoms in the interview had undertaken self-treatment. We believe that these workers do not identify their sensations as symptoms of health disorders or report them as such for cultural, educational and occupational reasons. These workers have a strong work ethic and are fearful of losing workdays or even their jobs. Additionally, focus group participants reported that unless painful symptoms are genuinely work disabling, it is unlikely that they will be reported as painful (*dolor* in Spanish); more frequently such sensations are reported as bothersome (*molestias*) and are regarded as commonplace occurrences to be endured rather than treatable disorders. The survey and our data collection process took these cultural variations into account.

While our sample of vineyards was not randomly selected and may not be fully generalizable to the industry, a suggested MSD incidence rate of 80 per 1,000 workers per year indicates a priority need. This is well above the rates targeted by the U.S. Public Health Service (1991) for an incidence of no more than 60 MSDs per 100,000 workers, and it confirms years of anecdotal evidence that field agricultural jobs are physically demanding and take a physical toll.

Our findings confirm our belief that a large proportion of reported sprain/strain (injury type) and overexertion injuries (injury cause) are indicative of high MSD incidence (AgSafe 1992). Furthermore, they help explain why so few workers perform these jobs beyond age 35 and raise our concern that we will find similarly high levels of MSD symptoms in other agricultural field jobs. Finally, these results point to a significant opportunity to reduce the risk of back injury in all jobs that require repeated lifting of heavy

loads by reducing load weights to 50 pounds or less.

### **A safer wine-grape harvest**

Manual wine-grape harvesting is highly strenuous and physically demanding work, involving exposure to serious risk factors for chronic back injury. Wine-grape harvest work involves all three of the priority ergonomics risk factors we have observed in other agricultural work: full-body stooped posture, highly repetitive hand-work, and manual lifting and carrying of heavy loads. Our findings show the physical impact of this work as a large increase in MSD symptoms during the 1997 standard-tub trial, with 70% of workers reporting symptoms.

Using ergonomic methods for risk-factor assessment and tool design, we reduced average tub weights by 19% to below the prescribed 50-pound threshold. This resulted in a two- to five-fold reduction in workers' postharvest symptom scores. Most importantly, at the end of the 1998 intervention-tub trial, both areas of significant force application related to tub lifting, back and knee, showed reductions of 50% in reported symptoms. These are large-magnitude health outcomes by any measure, and were achieved with no increase in symptoms for other body regions. Participating workers remarked upon this during the course of harvest. Nonetheless, while tub substitution resulted in an improved NIOSH Lifting Equation outcome from an LI of 3.4 to 2.4, it still left workers with an elevated risk of back injury (that is, exceeding the target LI of 1.0).

Equally important, the workers, whose endorsement of change is critical to the long-term success of an intervention, accepted the use of the smaller intervention tub. Despite a 2.5% decrease in worker productivity (measured by pounds of grapes per shift), neither workers nor managers remarked upon this. And because workers are paid on an incentive rate per ton rather than time, this decrease was of minor interest to managers. Because workers prefer the smaller tub for its easier manageability, they reported that the productivity decrease was not of critical interest either. All of the companies cooperating in our

project have permanently adopted the smaller picking tubs, which are commercially available, as have other vineyards throughout Napa and Sonoma counties. Taken all together, these results present a strong argument for reducing loads lifted or carried by hand (especially where repetition is a factor) to 50 pounds or less.

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# New controls investigated for vine mealybug

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*The vine mealybug is a newly invasive pest that has spread throughout California's extensive grape-growing regions. Researchers are investigating new control tools to be used in combination with or as an alternative to standard organophosphate insecticide controls. Insect growth regulators and nicotine-based insecticides provide good alternative pesticides for use in some vineyards. Ongoing studies on the augmentative release of natural enemies and mating disruption also show promise, but commercial products are not yet available to growers.*

In the early 1990s, the vine mealybug was accidentally introduced into the Coachella Valley (Gill 1994; Godfrey et al. 2003), probably from Mexican or Argentinian table-grape vineyards. This invasive pest quickly spread to grape-growing regions in the San Joaquin Valley (1998), Central Coast (1999), North Coast (2001), Sacramento Valley (2002), Sierra foothills (2002) and Monterey area (2002). As of fall 2005, the vine mealybug had been found in 17 California counties, and it is likely that more infestations have not been detected.

Vineyard mealybugs decrease crop quality by excreting honeydew, which promotes sooty molds, and by infesting grape bunches (Flaherty et al. 1992). The vine mealybug (*Planococcus ficus* [Signoret]) has biological characteristics that make it more damaging than other vineyard mealybugs (Godfrey et al. 2002). For example, the vine mealybug has a high reproductive rate, with some females depositing more than 250 eggs, and a fast development time, with four to seven generations per year in the San



The nonnative vine mealybug, female (left) and winged male (right), excretes abundant honeydew, and infests and feeds on grape leaves and bunches. The authors investigated sustainable alternatives to conventional insecticides, which are often ineffective because the mealybug can reside under the bark.



Joaquin Valley. In addition to producing abundant honeydew, the vine mealybug feeds on grape leaves and bunches through much of the summer. This pest also has a wide host range, which includes common weeds (such as malva), potentially increasing residual populations outside the vineyard. Finally, like other vineyard mealybugs, the vine mealybug can transmit grapevine viral diseases (Golino et al. 1999).

Unfortunately, the vine mealybug is a pest that is here to stay in California and will likely continue to spread. Its dissemination is facilitated by the sticky nature of the honeydew; infested plant material may be moved by wind-blown leaves, animals, farm equipment and field crews. Grape clusters harvested from infested vineyards may also promote the pest's movement to new vineyard blocks because some mealybugs can survive the destemming process and grower-managed compost piles. As a result, caution must be taken with the disposal of harvest waste. Finally, because mealybugs often reside beneath the vine's bark or underground, the detection of infested nursery stock is difficult and the effectiveness of contact insecticides is reduced.

In response to the serious consequences of vine mealybug infestations in California, a consortium of University, private, and county and state personnel has initiated regional trapping and control efforts (Daane, Bentley, et al. 2004). Effective, insecticide-based control programs have been developed for regions where the pest is well established. In a series of studies, we focused on more sustainable controls that may work in combination with or as alternatives to standard insecticide programs.

### Insecticide trials

Until recently, the recommended insecticide program for vineyard mealybugs was a delayed dormant organophosphate insecticide (chlorpyrifos [Lorsban, Dow Chemical]) and/or in-season applications of a short-residual organophosphate (e.g., diazinon [Helena Chemical]) or carbamate (e.g., methomyl [Lannate, DuPont]) (Bentley et al. 2003). While these insecticides can provide adequate vine mealybug control, their repeated use may also kill natural enemies of the mealybug, reducing the level of biological control (Walton and Pringle 1999). We studied the effectiveness of two insecticides considered less disruptive than the organophosphates: imidacloprid (Admire, Bayer), a systemic, nicotinoid insecticide; and buprofezin (Applaud, Nichino America), an insect growth regulator. We report here on a part of this larger study.

**Systemic insecticide.** In 2002, we tested the effectiveness of imidacloprid as a systemic insecticide (applied through irrigation water and taken up by the vine roots) at different timings. The study was conducted in two vineyards, one with drip and the other with furrow irrigation, near Del Rey (Fresno County). The vineyards were mature (more than 20 years old) 'Thompson Seedless' blocks, planted in a well-drained, sandy-loam soil and managed for raisin grapes.

In each vineyard, imidacloprid was applied at full label rate in a randomized complete block with five blocks, each containing the following five treatments: 32 ounces imidacloprid per acre applied in (1) April, (2) May or (3) June; (4) 16 ounces imidacloprid per acre applied in both April and May; and (5) a

no-insecticide control. Treatment plots were three rows by 80 to 125 vines (0.5 to 0.7 acres), running the length of each row. In the drip-irrigated vineyards, a 4- to 6-hour pretreatment irrigation prepared the soil. Imidacloprid was then applied through the irrigation system, and a 6- to 8-hour post-treatment irrigation was used to move the insecticide into the root zone. The furrow-irrigated vineyards were prepared by French plowing the berm and furrow area to expose surface roots, followed by a 1-day pretreatment irrigation. Imidacloprid was then applied into the furrows using an herbicide spray rig, and the application was followed by a 1-day posttreatment irrigation.

Mealybug density was monitored before treatment application (between March 13 and 19, 2002) by a field dissection of two spurs per vine on 25 randomly selected vines per plot for a total of 625 vines per vineyard (Geiger et al. 2001). To determine treatment effect, crop damage was evaluated at harvest using a 0-to-3 cluster rating system, where 0 = no mealybug damage, 1 = honeydew (indicating the presence of mealybugs), 2 = honeydew and mealybugs but the cluster is harvestable, and 3 = unmarketable (Geiger and Daane 2001). In each treatment plot, 25 vines were randomly selected and nine clusters per vine were sampled.

**Foliar treatments.** In 2003, we tested five treatments in the existing 2002 drip- and furrow-irrigated plots. The five treatments were: (1) 32 ounces imidacloprid per acre, applied in May 2003 to plots that had received the same treatment in April 2002; (2) no insecticide applied in 2003 to plots that had received 32 ounces imidacloprid per acre in May 2002; (3) 12 ounces buprofezin per acre,





**Left to right, the vine mealybug was introduced into California in the early 1990s, and is currently found in at least 17 counties; infested windblown leaves can easily spread the pest from vine to vine, and vineyard to vineyard; grape bunches are rendered unmarketable; a damaged grapevine trunk.**

applied in June 2003 to plots that had received 32 ounces imidacloprid per acre in June 2002; (4) 2 quarts chlorpyrifos per acre, applied in February 2003 to plots that had received 16 ounces imidacloprid per acre in both April and June 2002; and (5) no-insecticide control plots (same plots as in 2002).

Because the 2002 plots were retreated, we conducted a more detailed spring survey to determine if the preexisting mealybug density would affect the 2003 treatments. Mealybug density was determined in March 2003 using a 5-minute search on each of five randomly selected vines per plot (Geiger et al. 2001). To determine the treatment effect, crop damage was evaluated at harvest, as described previously.

### Natural enemy augmentation

As an alternative to insecticides, we investigated biological control of the vine mealybug. Natural enemies attacking the vine mealybug in California vineyards include the encyrtid parasitoids *Anagyrus pseudococci* (Girault), *Allotropa* sp. and *Leptomastidea abnormis* (Girault); several species of green and brown lacewings; and coccinellid beetles, including the mealybug destroyer, *Cryptolaemus montrouzieri* (Mulsant). Of these, *Anagyrus* is the most effective natural enemy of the vine mealybug in the San Joaquin Valley; as many as 90% of the exposed mealybugs collected near harvest time were parasitized (Daane, Malakar-Kuenen, et al. 2004). However, the parasitoid's effectiveness is hampered by at least four factors. First, from October to April vine mealybugs reside primarily underneath the bark, where they are protected from foraging parasitoids. Second, *Anagyrus* overwinter as immatures inside the mealybug and adults do not emerge

until late spring, further reducing their early-season densities (Daane, Malakar-Kuenen, et al. 2004). Third, foraging ants protect mealybugs from parasitoids (Daane, Sime, et al. 2004). And finally, the parasitoid prefers larger mealybugs, especially for the production of female parasitoids.

We tested inoculative releases of *Anagyrus* as a possible mechanism to overcome some of these barriers. Field studies were conducted in five mature Thompson Seedless vineyards that were managed for raisin grapes and located near Del Rey. Treatments were *Anagyrus* release and a no-release control, with 1-acre treatment plots set in a randomized split plot design, and each vineyard serving as a replicate. *Anagyrus* were provided by the Foothill Agricultural Research (FAR) Insectary. We released 10,000 *Anagyrus* per acre on June 12, July 3 and July 30, 2003, scheduled to occur when the mealybugs were in exposed locations on the vine (e.g., on the leaves).

Throughout the season, vine mealybug density was determined by 5-minute searches on each of 10 randomly selected

exception that we sampled 50 randomly selected vines per treatment plot and five clusters per vine.

### Disrupting mealybug mating

Until recently, a major hurdle in controlling mealybugs was the difficulty of detecting them in nurseries and vineyards. In 2001, a more effective monitoring method was developed utilizing the mealybug's sex pheromone. Female mealybugs, which are wingless, emit a sex pheromone to attract adult males, which have wings. This pheromone has been identified (Hinkens et al. 2001), synthesized and successfully used in monitoring programs (Millar et al. 2002; Walton et al. 2004). The synthetic sex pheromone's effectiveness and ability to be mass-produced led to our current studies on mating disruption of the vine mealybug.

We conducted studies in 2003 that used a microencapsulated formulation of the sex pheromone, applied to sections of five Thompson Seedless vineyards located near Del Rey, Sanger and Fowler (Fresno County). Treatments were phero-

## Selective insecticides, augmentation of natural enemies, and mating disruption programs could provide growers with better tools to manage the vine mealybug.

vines per treatment plot. Mealybug numbers were recorded by development stage (e.g., first, second or third instar and adult). Parasitoid activity was evaluated by collecting 100 mealybugs from each treatment plot, which were recorded by development stage and location, categorized either as "protected" (e.g., underground or under trunk bark) or "exposed" (e.g., on leaves or clusters). When possible, we selected mealybugs in a one-to-one ratio from exposed and protected locations. The collected mealybugs were stored in gelatin capsules and held for parasitoid emergence, and then percentage parasitism and parasitoid species were recorded. Crop damage was evaluated at harvest using the cluster rating system (method described previously), with the

mone applications (mating disruption) and a no-pheromone control, with 3- to 5-acre plots set in a randomized split plot design and each vineyard serving as a replicate. A 20- to 25-row buffer (330 yards) was used between treatment plots. The sex pheromone used was produced by Kuraray (Tokyo, Japan) and then microencapsulated by Suterra (Bend, Ore.). The pheromone was applied using an air-blast spray rig at a rate of 0.282 ounces active ingredient in 50 gallons of water per acre. Three applications were made in each field, with application dates between May 12 to 15, June 16 to 19, and Aug. 2 to 4.

Male mealybug flight was monitored using three Pherocon Delta IIID traps baited with sex pheromone lures (Suterra) in each treatment plot. Traps

and lures were changed every 2 and 4 weeks, respectively. Mealybug density was determined using a 5-minute search on each of 10 randomly selected vines per treatment plot (method described previously). Crop damage was evaluated at harvest (method described previously), on 20 randomly selected vines per treatment plot and five clusters per vine.

The microencapsulated formulation starts emitting sex pheromone immediately after application and its longevity is dependent on temperature. To determine the field longevity, samples of pheromone-treated and clean (control) leaves were compared for their attractiveness to adult mealybug males. Ten leaves each were randomly sampled from pheromone-treated and control vines at 1, 7, 14, 21, 28, 35 and 42 days after pheromone application. The leaves were placed individually on the sticky surface of a pheromone trap, which was then placed 3.4 yards from a mealybug colony. After 24 hours, the numbers of adult males in traps with treated or untreated leaves were counted.

### Statistical analysis

For all of these studies (insecticides, natural enemies and mating disruption), the results are presented as means per treatment ( $\pm$  SEM). Treatment impacts were compared using analysis of variance (ANOVA), with the means separated using Tukey's HSD test ( $P < 0.05$ ) for three or more treatments or using a *t*-test for two treatments. Treatment influences on cluster damage, as measured by the rating scale, were compared in a  $2 \times 2$  contingency table with treatments separated using Pearson's chi-square ( $P = 0.05$ ). Differences among specific treatments were evaluated as a series of pairwise comparisons, adjusting the critical value using the standard Bonferroni technique ( $P = 0.01$ ). Repeated measures ANOVA analyses were used to determine season-long differences in mealybug densities, percentage parasitism and pheromone trap catches.

### Alternatives to organophosphates

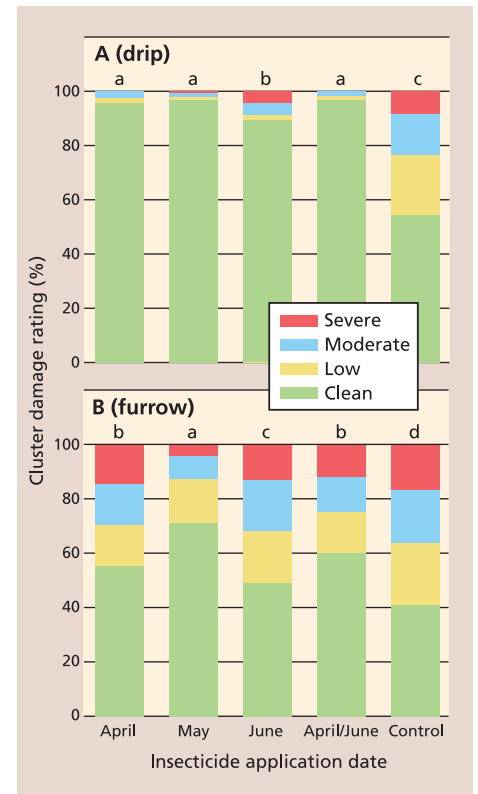
**Systemic insecticide.** In the drip-irrigated vineyard, there was a significant treatment impact on cluster damage ( $F = 1085.4$ ,  $df = 12$ ,  $P < 0.0001$ ). All treatments receiving imidacloprid, regardless of application date, had sig-

nificantly less cluster damage than the control (fig. 1A). Average cluster damage ratings in the April, May and April/June imidacloprid treatments were a significant 90.5%, 92.5% and 92.4% lower than in the control, respectively. Average cluster damage in the June imidacloprid treatment was a significant 67.9% lower than in the control, but significantly higher than in imidacloprid treatments applied earlier in the season.

In the furrow-irrigated vineyard, cluster damage ratings in all treatments with imidacloprid were significantly lower than the control ( $F = 221.58$ ,  $df = 12$ ,  $P < 0.0001$ ); however, there was a greater separation of the imidacloprid treatments (fig. 1B). Cluster damage in the May treatment was 59.3% lower than the control, and significantly lower than all treatments. Meanwhile, the April and April/June treatments were only 21.3% and 31.0% lower, respectively, than the control. The average cluster damage rating in the June application of imidacloprid was 14.8% lower than the control, but significantly higher than all other imidacloprid treatments.

The results show that imidacloprid provided the greatest reduction in cluster damage when applied in April or May through a drip-irrigation system, and was less effective when delivered through the furrow-irrigation system. We believe furrow-irrigated blocks have a more widespread root zone, which makes delivery of the insecticide to the entire root zone difficult and results in a more dilute application and poorer uptake of the applied imidacloprid. Irrigation both pre- and post-imidacloprid application is also critical, and this too is more difficult to properly manipulate with furrow irrigation.

It is important to note that these studies were conducted in the San Joaquin Valley on a sandy-loam soil; soil structure may change the efficacy of systemically applied materials. Imidacloprid and other systemic chloronicotinyls are moved with the irrigation water into the soil, picked up by the vine's root system, and then moved through the vine in its xylem. For this reason, proper delivery of imidacloprid may vary greatly among vineyards depending on soil and vine conditions. For example, there is evidence that the insecticide can bind with soil particles above the root zone when there



**Fig. 1. Percentage cluster damage ratings for imidacloprid and control treatments in (A) drip-irrigated and (B) furrow-irrigated vineyard. Clean = no mealybug damage; low = honeydew, indicating the presence of mealybugs; moderate = honeydew and mealybugs present; severe = unmarketable. Different letters indicate significant difference among treatments ( $P < 0.01$ ).**

is too little soil moisture, especially in heavier soils with higher clay content. In contrast, the insecticide may be flushed too quickly through and out of the root zone when too much water is applied in sandy soils. Once in the vine, imidacloprid must be delivered to sections where the mealybugs are feeding. Because all vineyard mealybugs are phloem feeders, there will be sections of the vine where the concentration and effectiveness of systemic insecticides vary (for example, the concentration of a systemically delivered insecticide may be higher in canes and lower in grape clusters). Researchers are currently investigating the uptake of systemic chloronicotinyls in the vine (N. Toscano, personal communication) and this information, developed for glassy-winged sharpshooter (*Homalodisca coagulata* [Say]), will greatly benefit mealybug control strategies.

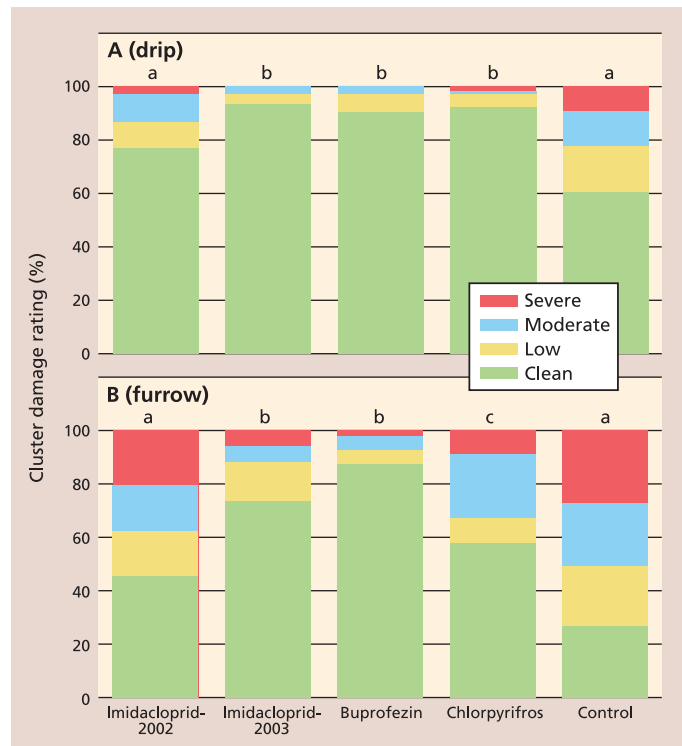
**Systemic vs. foliar insecticides.** In spring 2003, there were no significant pretreatment differences in mealybug densities among treatment plots in ei-

ther the drip- or furrow-irrigated vineyards (drip:  $F = 0.922$ ;  $df = 4, 145$ ;  $P = 0.453$ ; or furrow:  $F = 1.518$ ;  $df = 4, 145$ ;  $P = 0.200$ ). Therefore, treatment impact was not obscured by pretreatment differences resulting from the previous year's insecticide application.

In the drip-irrigated vineyard, there was a significant treatment impact on cluster damage ratings ( $F = 221.58$ ,  $df = 12$ ,  $P < 0.0001$ ). Pairwise comparisons of the ratings for individual treatments were a significant 87.3%, 82.7% and 85.0% lower in the imidacloprid-2003, buprofezin and chlorpyrifos treatments, respectively, as compared to the control (fig. 2A). There was no difference between the imidacloprid-2002 application and the control. In the furrow-irrigated vineyard, there was a significant treatment impact on cluster damage ratings ( $F = 132.96$ ,  $df = 12$ ,  $P < 0.001$ ) (fig. 2B). The most effective treatments were imidacloprid-2003 and buprofezin, where cluster damage was 70.7% and 85.6% lower than the control, respectively. There was a significant 44.1% reduction in the chlorpyrifos treatment, whereas cluster damage in the imidacloprid-2002 treatment was not significantly different from that in the control (fig. 2B).

The fact that there was no significant difference between imidacloprid applied in 2002 and the control suggests that there was not an adequate year-to-year carryover of imidacloprid in the soil or root systems for vine mealybug control. The poor control achieved with chlorpyrifos in the furrow-irrigated block may be due to the location of the vine mealybug population in this vineyard, which had older vines (more than 30 years) that provided many protective areas under the bark of the trunk and spurs where mealybugs could remain hidden during much of the spring.

**Control programs.** Imidacloprid provided the greatest reduction in cluster damage when applied in April or May through a drip-irrigation system. We recommend that imidacloprid be applied near 70% bloom, typically from late April to mid-May. As noted, imidacloprid was less effective when delivered through the furrow-irrigation system. Even when properly timed (May) and delivered (pre- and postapplication irrigation), a single imidacloprid application did not locally extirpate vine mealybugs. In fact,



**Fig. 2. Percentage cluster damage ratings for insecticide and control treatments in (A) drip-irrigated and (B) furrow-irrigated vineyard. Clean = no mealybug damage; low = honeydew, indicating the presence of mealybugs; moderate = honeydew and mealybugs present; severe = unmarketable. Different letters indicate significant difference among treatments ( $P < 0.05$ ).**

the vine mealybug population recovered in all imidacloprid treatment plots between summer 2002 and spring 2003. This is presumably because imidacloprid cannot reach all parts of the vine, which leaves small pockets of mealybugs that can recolonize. Currently, ongoing investigations are determining the movement and concentration of systemically applied nicotenoic compounds, like imidacloprid, to different sections of the vine (personal communication, N.C. Toscano).

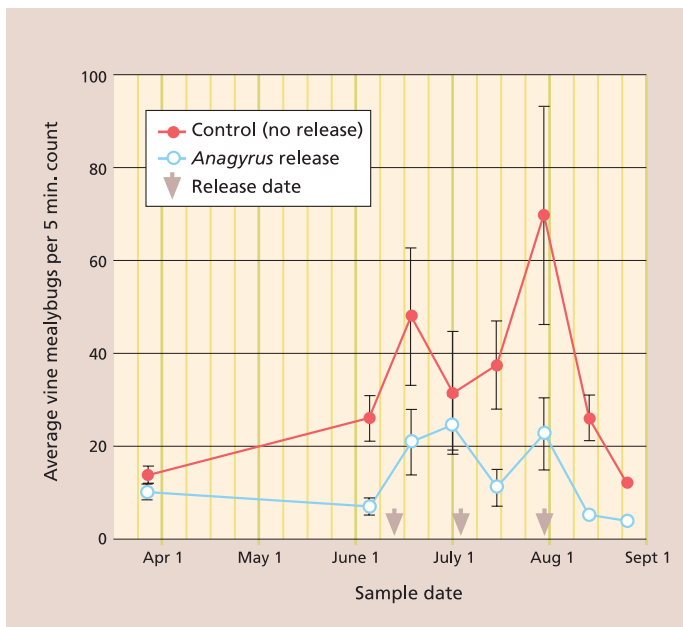
Buprofezin provided excellent control, comparable to both imidacloprid and chlorpyrifos, and can be used effectively in vineyards with furrow-irrigation systems. We recommend that buprofezin be used as an alternative to in-season organophosphate treatments. Because buprofezin is an insect growth regulator, it is most effective on smaller mealybugs undergoing insect molts. For this reason, it will have greater impact when applied earlier in the season, before the mealybug population has overlapping generations. It will be least effective postharvest because late in the season (October and November) the development of most mealybugs has slowed and the population often consists primarily of adults and ovisacs.

### Parasitoids help control mealybug

The season-long mealybug density was significantly lower in the *Anagyrus* release than in the control treatment

(fig. 3). The average cluster damage rating was 57% lower in the *Anagyrus* release ( $0.22 \pm 0.03$ ) than in the control ( $0.51 \pm 0.05$ ) treatment ( $t = 5.52$ ;  $df = 1, 444$ ;  $P < 0.001$ ). However, we are unable to conclude that the released *Anagyrus* were solely responsible for this reduction. First, while there was no treatment difference in vine mealybug density on March 27 ( $t$ -test = 1.66,  $P = 0.101$ ), which was when the treatment plots were randomly assigned, there were fewer mealybugs on June 5 ( $t$ -test = 3.70,  $P < 0.001$ ), which was just before the *Anagyrus* release. Second, there was no season-long difference in percentage parasitism (repeated measures ANOVA:  $F = 2.11$ ;  $df = 1, 521$ ;  $P = 0.15$ ), although this is often an unreliable tool to measure the impact of natural enemies.

Nevertheless, the results provide encouraging information for the commercial use of *Anagyrus* to control vine mealybug. From 7,458 mealybugs collected and held in gelatin capsules, 1,978 were parasitized (26.5%) and 1,235 parasitoids were reared to the adult stage. The parasitoids reared were *Anagyrus*, *L. abnormis*, *Allotropa* sp. and *Chartocerus* sp. (the *Chartocerus* is a hyperparasitoid, which is probably attacking *Anagyrus*). *Anagyrus* was the dominant adult parasitoid, comprising more than 93% of the total (table 1). Third-instar mealybugs were most commonly attacked, reflect-



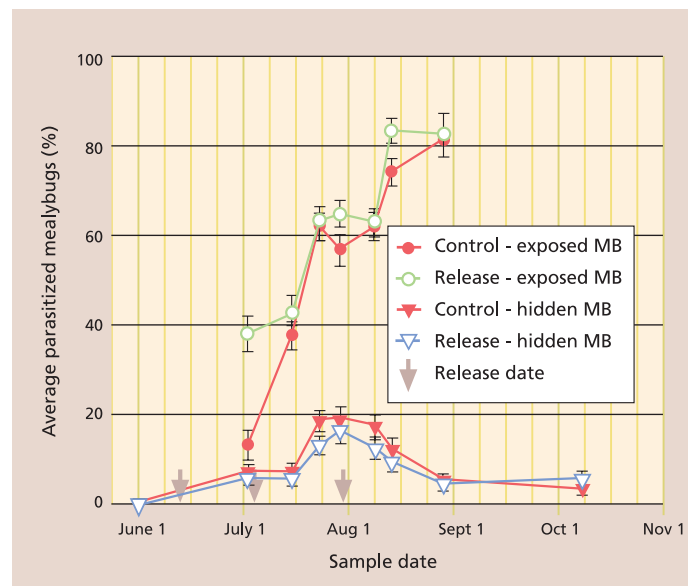
**Fig. 3.** Season-long average ( $\pm$  SEM) of settled (second instar to adult) vine mealybugs was significantly lower in treatments with *Anagyrus pseudococci* release, as compared to non-insecticide control plots (repeated measures ANOVA:  $F = 13.27$ ;  $df = 1, 76$ ;  $P < 0.001$ ).

ing the host preference of *Anagyrus*. Mealybug size affected the gender of the reared *Anagyrus*: first- and second-instar mealybugs yielded primarily males (100% and  $83.3\% \pm 1.1\%$ , respectively), whereas third-instar and adult mealybugs yielded primarily females ( $95.4\% \pm 1.1\%$  and  $92.9\% \pm 2.2\%$ , respectively).

Season-long percentage parasitism, with data separated by date and location of collected mealybugs, shows the importance of timing augmentative releases after mealybugs have moved from protected locations (fig. 4). While the season-long percentage parasitism of mealybugs collected from protected locations (such as under bark) never exceeded 20%, there was a consistent season-long rise in parasitism of mealybugs collected from exposed locations

(such as on the leaf). On the June 1 sampling date, which was prior to *Anagyrus* release, no mealybugs could be found in exposed locations. After releases began, there was a significantly greater percentage parasitism of exposed mealybugs in the release than in control plots on the initial sample (fig. 4). Parasitism rose steadily in both release and control plots because of the strong resident population of *Anagyrus* in this untreated field, reaching more than 80% by late August, after which we could find no live mealybugs in exposed locations.

**Year-to-year declines.** Resident *Anagyrus* are providing significant reductions in late-season vine mealybugs, which form the base for the following season's mealybug population. In fact, we have recorded a year-to-year decline in mealybug abundance in sampled



**Fig. 4.** Season-long average ( $\pm$  SEM) percentage parasitism of settled (second instar to adult) vine mealybugs (MB), with data separated by treatment and location where mealybugs were collected. Season-long percentage parasitism was significantly higher in exposed than hidden locations for both control (repeated measures ANOVA:  $F = 247.3$ ;  $df = 1, 273$ ;  $P < 0.001$ ) and release (repeated measures ANOVA:  $F = 501.5$ ;  $df = 1, 249$ ;  $P < 0.001$ ) treatments.

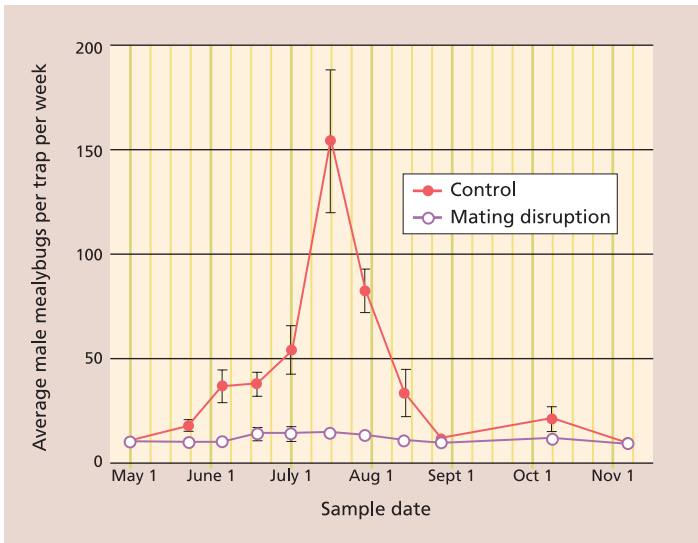
vineyards near Del Rey. We are also enthusiastic about the commercial potential of *Anagyrus* and note the low rating for average cluster damage in the release treatment, which showed that an average of 78% of all clusters were clean and the remaining 22% had only minor honeydew damage.

The results of *Anagyrus* percentage parasitism and mealybug host stage preference will also help develop future release strategies. For example, most live mealybugs in the September and October samples were found in protected locations of the vine, such as under the bark. These protected locations greatly reduce the ability of foraging *Anagyrus* to locate and parasitize vine mealybugs. We believe this results in lowered parasitism levels of the overwintering mealybug population, leading to the observed low levels of *Anagyrus* the following spring (fig. 3).

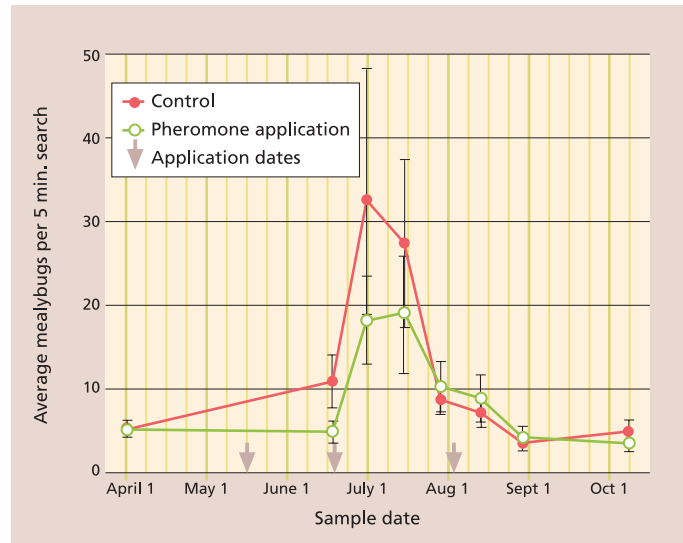
Furthermore, we reared primarily male *Anagyrus* from first- and second-instar mealybugs. These results show that *Anagyrus* releases should be timed to coincide not only with the presence of mealybugs in exposed locations, but also with the presence of third-instar mealybugs, which are needed to support the production of female *Anagyrus*.

**TABLE 1.** Percentage parasitism and parasitoid species composition, by vine mealybug development stage

Mealybug development stage	Parasitism	Parasitoid species			
		<i>Anagyrus pseudococci</i>	<i>Allotropa</i> sp.	<i>Leptomastix abnormis</i>	<i>Chartocerus</i> sp.
% ( $\pm$ SEM)					
First instar	4.7 $\pm$ 0.5	97.2 $\pm$ 2.8	2.8 $\pm$ 2.8	0	0
Second instar	37.9 $\pm$ 0.9	89.0 $\pm$ 1.1	7.2 $\pm$ 0.9	2.3 $\pm$ 0.6	1.5 $\pm$ 0.4
Third instar	53.2 $\pm$ 1.4	90.4 $\pm$ 1.3	7.6 $\pm$ 1.2	0.2 $\pm$ 0.2	1.8 $\pm$ 0.3
Adult	11.1 $\pm$ 0.8	93.0 $\pm$ 1.2	4.0 $\pm$ 1.2	0	3.0 $\pm$ 1.1
Total	26.5 $\pm$ 0.5	92.1 $\pm$ 0.7	5.5 $\pm$ 0.6	0.7 $\pm$ 0.3	1.7 $\pm$ 0.3



**Fig. 5.** Season-long average ( $\pm$  SEM) pheromone trap catches of adult male vine mealybugs in mating disruption and no-insecticide control treatments were significantly different (repeated measures ANOVA:  $F = 15.27$ ;  $df = 1, 6$ ;  $P = 0.008$ ).



**Fig. 6.** Season-long average ( $\pm$  SEM) of settled (second to adult stage) vine mealybugs in mating disruption and no-insecticide control treatments were not significantly different (repeated measures ANOVA:  $F = 1.85$ ;  $df = 1, 77$ ;  $P = 0.18$ ).

### Mating disruption promising

One of the five vineyard blocks was partially treated with chlorpyrifos; this vineyard was removed from the data analysis and will be discussed separately. In the remaining four vineyards, season-long male mealybug trap catches were significantly lower in the mating disruption treatment than in the control (fig. 5). Essentially, pheromone traps were “shut down” in the mating disruption treatment because the vineyard was so inundated with sex pheromone that the vine mealybug males could not find the traps. More importantly, there was a significant reduction in crop damage in the mating disruption treatment ( $t$ -test:  $t = 5.76$ ,  $P < 0.001$ ), with most of the clusters rated 0, or clean, and hardly any rated 3, or unmarketable ( $90.5\% \pm 1.5\%$  and  $1.2\% \pm 0.2\%$ , respectively).

However, while crop damage was lower, season-long mealybug densities were not significantly different between the pheromone and control treatments (fig. 6). We believe that this may be explained by differences in mealybug location on the vine. For example, in the pheromone-treated plots, most live mealybugs were found under the bark on the trunk, while in the control they were under the bark, and exposed in leaves and clusters. We believe the between-treatment difference in mealybug location results from a beneficial artifact of the mating disruption: we consistently found higher parasitism rates of the exposed mealy-

bugs in the mating disruption plots. This increase in parasitism levels in mating disruption plots has also been found in a recent South African study (Walton and Daane, unpublished data). *Anagyrus* may cue in on the mealybug pheromone and either remain in the vineyard aggressively searching for mealybug hosts, or be pulled in from nearby vineyards.

As mentioned previously, the cluster damage rating was lower in the mating disruption plots. Nonetheless, our research suggests that mating disruption may not be the most effective tool to quickly lower high-density mealybug populations. First, mating disruption works more slowly because it prevents the next generation from forming rather than killing the mealybugs already present. Second, mealybug density appears to influence the effectiveness of vine mealybug mating disruption.

In our trials, the overall level of crop damage was low even in the control treatment, with about 80% of the clusters clean (rated 0 or 1). This was in part by design, as earlier studies with mating disruption in heavily infested vineyards showed no treatment effect (Walton and Daane, unpublished data). We suspect that this may be due to the fact that at high mealybug densities, adult males would emerge in close proximity to females. Therefore, for these trials we selected vineyards with initially low or moderate mealybug densities. Still, there was even less damage in these vineyards than expected, consider-

ing that a few years before there had been nearly complete crop loss. We found that much of the mealybug reduction was the result of natural parasitism levels by *Anagyrus*. Clearly, the mating disruption program is quite compatible with biological control.

Currently, we are testing mating disruption programs that deliver the pheromone either as a microencapsulated formulation (provided by Suterra) or in dispensers (provided by Suterra, Shin-Etsu Chemical [Tokyo, Japan] and Scentry Biologicals [Billings, Mont.]). The advantages of the microencapsulated formulation include application using standard pesticide rigs, the dispersion of millions of microcapsules per acre to provide thorough coverage, and numerous point sources on each vine. One disadvantage, found in the 2003 study, is that pheromone activity was depleted after only 21 days; therefore, multiple applications per season are required. However, the longevity of product delivery (either in microcapsules or dispensers) is a technical problem that may be solved in product formulation. The advantages of dispensers are that they can be applied by hand, have the potential for longer activity (and so one or two applications per season), and have the potential for use in California certified organic farms.

### Sustainable pest treatments

The vine mealybug is a serious pest that is here to stay. Along with its po-



**Left to right, Jose Tinoco places a pheromone trap; Raksha Malakar-Kuenen, a postdoctoral researcher, samples for mealybugs; UC Riverside entomologist Jocelyn Millar and colleagues synthesized a vine mealybug sex pheromone, which has allowed for more effective monitoring.**

tential for damaging vines and reducing marketable yields, it often requires the considerable use of insecticides. While properly timed insecticide applications provide excellent control, their increased use runs counter to the grape industry's move toward sustainable farming methods.

Presently, organophosphates, nicotinioids (imidacloprid) and insect growth regulators (buprofezin) are being used in vine mealybug control programs. Selection of the proper material or combination will depend on the time of year, mealybug density and vineyard condition (for example, imidacloprid may work best on sandy-loam soils). Selective insecticides, augmentation of natural enemies and mating disruption programs could provide growers with better tools to manage the vine mealybug.

Nevertheless, continued vigilance is needed to reduce populations and limit the pest's further spread. Growers should train all their workers in mealybug identification and react quickly to any new finds. Managers of infested blocks should follow all the recommended treatment protocols ([www.ipm.ucdavis.edu/PMG/r302301911.html](http://www.ipm.ucdavis.edu/PMG/r302301911.html)), and manage their equipment and workforce to minimize this pest's spread. Wineries should be aware of the status of vineyards delivering fruit and take steps to properly dispose of stems coming from infested blocks. Grapevine nurseries should implement quality-assurance measures to prevent the vine mealybug's further spread on plant materials.

By implementing appropriate control measures, the overall impact and dissemination of the vine mealybug will be reduced. Different regions vary in levels of vine mealybug infestation, and some

regions may have compliance agreements in place for required treatments; growers should contact their local UC Cooperative Extension or county agricultural commissioner's office for information.

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The following research articles, news stories and editorials appeared in *California Agriculture*, Volume 59, Numbers 1 through 4, January through December 2005; numbers are Jan-Mar (1), Apr-June (2), July-Sept (3) and Oct-Dec (4).

**KE** = Kearney REC 40th anniversary special issue  
**OP** = Beyond Organophosphates special issue  
 \* = Sidebars

Back issues may be purchased for \$5 per copy, while supplies last; go to <http://CaliforniaAgriculture.ucop.edu> or send orders to *California Agriculture*, 1111 Franklin St., 6th floor, Oakland, CA 94607, and make checks payable to UC Regents. The complete contents of all 2005 issues, including PDF versions of research articles, can be found online at <http://CaliforniaAgriculture.ucop.edu>.

## Research and review articles

### Animal, avian, fisheries & veterinary

PCR and antibody methods: Research compares two cattle feed tests that detect bovine byproduct contaminants — Sawyer et al. *Oct-Dec* p212

U.S. beef industry faces new policies and testing for mad cow disease — O'Neill *Oct-Dec* p203

### Economics and public policy

Costs of 2001 methyl bromide rules estimated for California strawberry industry — Carter et al. *Jan-Mar* p41

### Land, air and water sciences

Deep vadose zone hydrology demonstrates fate of nitrate in eastern San Joaquin Valley — Harter et al. *Apr-June* p124 **KE**

Drip irrigation can effectively apply boron to San Joaquin Valley vineyards — Peacock, Christensen *July-Sept* p188

Ozone reduces crop yields directly and alters crop competition with weeds such as yellow nutsedge — Grantz, Shrestha *Apr-June* p137 **KE**

Soil sterilization and organic carbon, but not microbial inoculants, change microbial communities in replanted peach orchards — Drenovsky, Duncan, Scow *July-Sept* p176

Weighing lysimeters aid study of water relations in tree and vine crops — Johnson et al. *Apr-June* p133 **KE**

### Natural resources

Graphical analysis facilitates evaluation of stream-temperature monitoring data — Tate et al. *July-Sept* p153

Managed grazing and seedling shelters enhance oak regeneration on rangelands — McCreary, George *Oct-Dec* p217

Monitoring helps reduce water-quality impacts in flood-irrigated pasture — Tate et al. *July-Sept* p168

Statistical analysis of monitoring data aids in prediction of stream temperature — Tate et al. *July-Sept* p161

### Pest management

Almond growers rely on pest control advisers for integrated pest management — Brodt et al. *Oct-Dec* p242

Biological and cultural controls . . . Nonpesticide alternatives can suppress crop pests — Mills, Daane *Jan-Mar* p23 **OP**

Conventional and molecular assays aid diagnosis of crop diseases and fungicide resistance — Michailides et al. *Apr-June* p115 **KE**

Food Quality Protection Act launches search for pest management alternatives — Van Steenwyk, Zalom *Jan-Mar* p7 **OP**

Healthy Schools Act spurs integrated pest management in California public schools — Geiger, Tootelian *Oct-Dec* p235

Imported parasitic wasp helps control red gum lerp psyllid — Dahlsten et al. *Oct-Dec* p229

Introduced parasitic wasps could control glassy-winged sharpshooter — Pilkington et al. *Oct-Dec* p223

Large bugs damage pistachio nuts most severely during midseason — Daane et al. *Apr-June* p95 **KE**

Managing resistance is critical to future use of pyrethroids and neonicotinoids — Zalom, Toscano, Byrne *Jan-Mar* p11 **OP**

Microorganisms and their by-products, nematodes, oils and particle films have important agricultural uses — Godfrey et al. *Jan-Mar* p35 **OP**

Mulches reduce aphid-borne viruses and whiteflies in cantaloupe — Summers, Mitchell, Stapleton *Apr-June* p90 **KE**

Pheromone mating disruption offers selective management options for key pests — Welter et al. *Jan-Mar* p16 **OP**

Reduced-risk fungicides help manage brown rot and other fungal diseases of stone fruit — Adaskaveg et al. *Apr-June* p109 **KE**

Various novel insecticides are less toxic to humans, more specific to key pests — Grafton-Cardwell et al. *Jan-Mar* p29 **OP**

### Plant sciences

Blueberry research launches exciting new California specialty crop — Jimenez et al. *Apr-June* p65 **KE**

Covering hay in the irrigated Sonoran Desert decreases heat damage — Guerrero, Lopez, Cervantes *Oct-Dec* p252

Early harvest delays berry skin browning of 'Princess' table grapes — Vial, Crisosto, Crisosto *Apr-June* p103 **KE**

English walnut rootstocks help avoid blackline disease, but produce less than 'Paradox' hybrid — Grant, McGranahan *Oct-Dec* p249

Labor costs may be reduced . . . Research yields size-controlling rootstocks for peach production — DeJong et al. *Apr-June* p80 **KE**

Methyl bromide alternatives . . . Soil solarization provides weed control for limited-resource and organic growers in warmer climates — Stapleton et al. *Apr-June* p84 **KE**

Orchard-system configurations increase efficiency, improve profits in peaches and nectarines — Day, DeJong, Johnson *Apr-June* p75 **KE**

Site-specific herbicide applications based on weed maps provide effective control — Koller, Lanini *July-Sept* p182

The future of California raisins is drying on the vine — Peacock, Swanson *Apr-June* p70 **KE**

## News departments

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Collaboration fosters Kearney scientific achievements — Grantz, Manton, Swanson *Apr-June* p33

UC expertise helps guide BSE response — Klingborg, Osburn, *Oct-Dec* p195

\* A brief history of BSE — Klingborg, Osburn *Oct-Dec* p197

### Editorials

ANR pursues excellence in research, development and delivery — Standiford *July-Sept* p146

Environmental laws elicit evolution in pest management — Van Steenwyk, Zalom *Jan-Mar* p2

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Agricultural innovation marks 40 years at Kearney *Apr-June* p56

\* Legendary "mother" pistachio tree to be retired *Apr-June* p59

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### Outreach news

Beef quality program meets evolving consumer and producer concerns *July-Sept* p151

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Survey seeks to improve sudden oak death outreach *Oct-Dec* p202

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"Farm to palate" postharvest research ensures high-quality produce *Apr-June* p62

Monitoring aids control of ag-related stream-temperature increases *July-Sept* p149

New BSE cases limit U.S. beef exports, change cattle testing *Oct-Dec* p198

\* Feed tests, models helping to control BSE *Oct-Dec* p199

UC nematologists battle tiny underground pests *Apr-June* p63

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Lygus study validates treatment thresholds *Apr-June* p64

Pyrethroids in Central Valley stream sediments toxic to bottom-dwellers *Jan-Mar* p5

State announces new methyl bromide use rules; phase-out delayed *Jan-Mar* p5

Three of four county anti-GMO measures fail *Jan-Mar* p6

## COMING UP . . .

Upcoming issues of *California Agriculture* will feature the following peer-reviewed research:

Attracting bats to Central Valley farms



Foliar sprays for boron deficiency



Update on yellow starthistle infestations



Dietary quality of African-American women

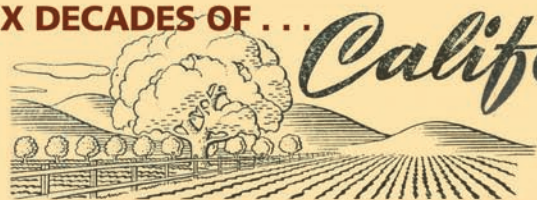


Cattle prices in Western video markets



Evapotranspiration of processing tomatoes

SIX DECADES OF . . .



California

# AGRICULTURE

60 years ago

50 years ago

40 years ago

30 years ago

December 1946:

## University President Discusses Work of College of Agriculture And Its Value to the Farmers

*Editor's note: The first issue of California Agriculture — a four-page, black-and-white, newsprint tabloid — was published in December 1946 (nameplate shown above). In honor of the magazine's 60th anniversary, we will be publishing excerpts from past decades throughout the year.*

It would be possible to tell the farmers of California just what the University's College of Agriculture has done for them, measured in dollars and cents.

That could be done, but the time and money required to obtain the figures can be better spent, we believe, in active attack upon the farmer's problems.

In one county, the recent discovery of methods of control of a disease affecting potatoes, developed by the plant pathology division, meant a million dollars to the growers last year; in another county, where the

University bulls were lent to dairymen, the average butterfat production per cow has been raised from 186 to 289 pounds, amounting to a total increase of six and one-half million pounds of butterfat.

There are underway at present, or just completed, 839 research projects in the College of Agriculture. Some of these agricultural enigmas, like Pierce's disease of grapevines, and mastitis of dairy cattle, still baffle scientists.

A new periodical (*This is the first issue.—Ed.*) will bring the farmer knowledge of projects launched, and of progress as it is being made, before the results are formally published for the recording of scientific accomplishment.

Looking backward over the years through which the College of Agriculture has served the State, I hope you will agree with me that it deserves the encomium, Well done!

— Excerpted from President Sproul's address to the California Farm Bureau Federation, Santa Cruz, Oct. 30, 1946. Current UC President Robert C. Dynes addressed the Farm Bureau in December 2005; see his comments at: <http://universityofcalifornia.edu/president/speeches.html>.



### Headlines from first year:

**"Army of 23 Million Wasps Is Winning Fight To Control the Oriental Fruit Moth in State"** (December 1946)

**"Removal of DDT Residue From Pears, Apples Successfully Accomplished By Washing"** (January 1947)

**"Continuous Production of California Timber Can Yield Profitable Returns"** (January 1947)

**"2,4D Valuable as Weed Killer When Properly Used But Can Be Detrimental To Soil and Crops if Mishandled"** (February 1947)

**"Steamed Cull Limas Palatable Protein Source for Hogs"** (February 1947)

**"Over 1100 Recognized Soil Types Represented in Twelve Regions Of State's 100,000,000 Acres"** (March 1947)

**"Spring Management of Honeybee Colonies Determined by Colony Needs Rather Than By Calendar"** (March 1947)

**"Further Improvements Needed Before Mechanization of Cotton Growing Reaches Full Efficiency"** (March 1947)



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