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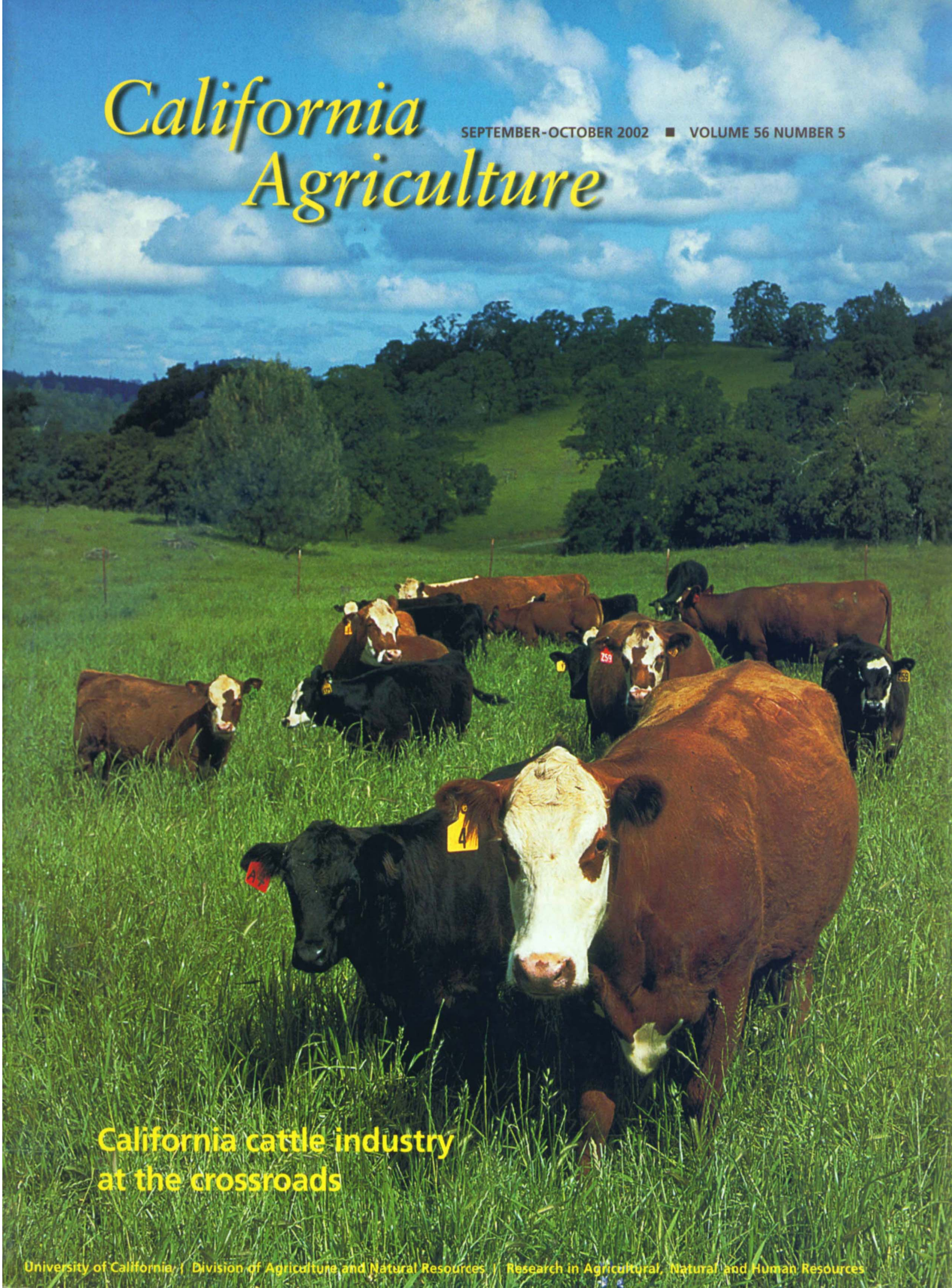

California cattle industry at the crossroads

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

Market consolidation poses challenges for food industry

Richard J. Sexton
Director,
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Economics

The structure of food marketing is changing rapidly in ways that affect the welfare of producers and consumers. Food manufacturing and retailing are becoming more concentrated. The top six supermarkets now control over 50% of supermarket sales, compared to 32% in 1992. The top 20 food manufacturers now account for over 50% of value added in processing, more than double their corresponding share in 1954. Likewise, the beef processing industry has experienced dramatic structural changes since the late 1970s. The confluence of declining demand for red meats and new, scale-intensive packing technology led to rapid consolidation in the packing sector, which today is dominated by four firms with a combined market share in excess of 80%. This market revolution has had serious implications for California ranchers (see p. 152). Today, a significant percentage of cattle leave the state for feeding and slaughter.

Food marketing is also becoming more streamlined. Traditional roles of wholesalers and brokers have declined in importance or been eliminated through vertical integration. Much of fresh produce, for example, now is sold directly from grower-shippers (marketers) to grocery retailers. Finally, traditional exchange mechanisms, such as central auctions and terminal markets, have declined in favor of contractual arrangements that commit producers to sell to a particular processor or retailer.

In many cases consolidation has been driven by efficiency considerations. In beef packing, UC Davis research has demonstrated that larger processing plants are indeed more efficient. Such efficiency gains in food marketing can produce benefits at both ends of the spectrum — lower prices for consumers and higher prices for producers. U.S. consumer prices for food and beverages have in fact risen more slowly than prices in general. From a 1982–1984 base period through 2001, food and beverage prices paid by U.S. urban consumers rose 73.6% compared to a 77.1% escalation in overall prices.

However, the share of the U.S. food dollar going to the farmer is actually decreasing in favor of the marketing sector. Although the farm share of USDA's "market basket" (a standardized set of food products bought in grocery stores) remained stable at about 40% from 1960 to 1980, it has declined rapidly since then, to about 20% today.

One inevitable effect of consolidation is fewer selling opportunities for farmers and ranchers. Two immediate challenges follow as a consequence: How to "discover" a fair market price, and how to ensure that fair value is paid. As the number of marketers declines and contract selling increases, centralized spot or auction markets decline or disappear. Spot markets that lack substantial competition on either the buying or selling side are vulnerable to manipulation. If confidence in a market is eroded, use of it will decline, exacerbating these problems.

Food consumers are increasingly quality conscious, and contracts between retailers or processors and producers are a good way to increase coordination and transmit information about consumer preferences. However, many observers also point to problems associated with the increasing use of contracts.

Because contracts are normally not negotiated in an open-market environment, how should price terms be set? A common method in California (such as for processing tomatoes, canning peaches, dried plums and pears) is to set contract terms through bargaining between processors and a grower association. In other instances, such as cattle and hogs, contract terms are tied to a corresponding spot-market price. As a result, any problems in the spot market immediately transmit to contracts as well. Recent UC Davis research has shown that opportunities for manipulation are created when contract prices are linked to a spot price, and some buyers operate in both markets. Another possibility is to link contract prices to "downstream" prices that the processor receives from retailers. However, retailers are increasingly requesting that processors perform services or pay various off-invoice fees. The very concept of a "price" received by the food manufacturer is no longer clear.

The second major concern about contracts is that they erode producers' traditional freedom to make decisions. The most extreme case is broiler contracts in the southern and eastern United States. Processors own the chicks and also provide feed, medicine and detailed growing instructions. The producer, who provides chicken houses and labor, has little discretion. Some analysts see the pork and cattle industries heading in the same direction. This issue surfaced in the 2002 Farm Bill, when legislation to ban packer ownership of hogs and cattle and limit packer control of production via contracts passed the Senate, but was not included in the final bill. This debate continues, however.

The revolution in food marketing raises interesting and important public policy issues. It has been driven by the economies of large-scale operations and the need to foster better coordination throughout the production and marketing chain to ensure the quality of production that the market now demands. By some measures the revolution has succeeded. Food in the United States remains relatively cheap and quality and variety have probably never been greater. The challenges lie in ensuring fair prices for producers, preserving farming as an independent occupation, and maintaining the vitality of the rural communities that are supported by U.S. agriculture.

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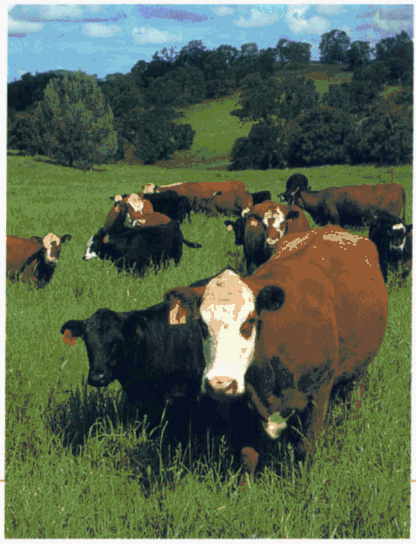
COVER: Beef cattle and calves are among California's top commodities, with a farm- gate value of $1.36 billion in 2001. But with increasing packer consolidation and declining demand for red meat, the state's cattle industry faces major challenges (p. 152). An option for some ranchers may be to pursue niche markets such as grass-fed beef (p. 151). In the dairy industry, organic production has emerged as a niche market (p. 157). Ranked as California's number one commodity, dairy generated $4.6 billion in 2001 and spurred growth in the hay sector, which now constitutes the largest crop acreage in the state. Choices made by alfalfa growers and dairy producers can help protect water quality and aquatic life (pp. 148, 150, 163). Research beef cattle graze at the UC Sierra Foothills Research and Extension Center. *Photo by Jack Kelly Clark*



News departments

Research articles

Kudos for *California Agriculture* articles

California Agriculture's coverage of grandparenting has received top honors from the National Extension Association of Family and Consumer Sciences (NEAFCS). The research article, "Numbers rising . . .Grandchildren raised by grandparents a troubling trend" (March-April 2001), by Alameda County family and consumer sciences advisor Mary Blackburn, was selected as the first place national winner in the NEAFCS Communications Awards — Written News category. The article also won first place in same category in the Western region. Blackburn's article used census data to quantify the numbers of grandchildren living in grandparent-headed households in California, and discussed efforts to provide needed services to this at-risk community. She will receive the awards during the NEAFCS annual conference in Kansas City, Mo., in October.

Another award winner was Lita Charlot, senior writer for ANR Spanish Broadcast and Media Services, for her Spanish translation of a *California Agriculture* research article. Charlot received a First Place Award, Outstanding Political Article, from the National Association of Hispanic Publications (NAHP) for "El Valle Central: Prosperidad agrìcola dentro de un marco de pobreza." The article was adapted from "The new rural poverty . . .Central Valley evolving into patchwork of poverty and prosperity" by J. Edward Taylor and Philip L. Martin (January-February 2000). One of more than 900 entries, it was submitted by *El Observador*, a bilingual newspaper in San Jose.

Sun setting on water quality exemptions

California agriculture's exemption from Clean Water Act provisions is set to expire in 2003. Growers may be required to develop plans for limiting pollution of natural waterways to protect beneficial uses such as fishing, swimming and wildlife habitat. Four-year-old Eugene Long plays in source water for sunflower irrigation on his family's Yolo County farm.

Traces of diazinon are in the Sacramento River. Chlorpyrifos has been discovered between the banks of the San Joaquin. Federal officials say tiny amounts of these and other pollutants impair hundreds of California rivers, creeks, streams and sloughs.

The environmental group DeltaKeepers has filed a series of petitions and lawsuits to require cleanup of California surface waters. "There are 5 million acre-feet of tail water coming from agricultural fields in California, transported through 6,000 to 15,000 miles of drainage channels to an unknown number of outfalls, at unknown locations with unknown pollutants," DeltaKeepers executive director Bill Jennings says. "We need to identify these."

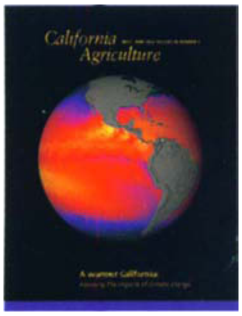
Farmers are also concerned, says John Garner, a Glenn County farmer who chairs the California Farm Bureau Federation's water advisory committee.

"Our livelihood depends on being ecologically balanced," Garner says. "Farmers are problem-solvers. We want to sit down with people involved in the process, come up with a workable solution, do it and get on with farming."

The federal Clean Water Act of 1972 set the stage for the current controversy. The law requires states to evaluate surface waters in order to determine where pollutants are adversely affecting beneficial uses, such as fishing, swimming and wildlife habitat. It also requires that sources of pollutants be identified and then limited. (Total maximum daily load [TMDL] limits must be established for each pertinent pollutant in regulated waterways.) As a result, California compiled a list of 509 impaired waterways and began efforts to clean them up.

The California Water Code, adopted in 1982, also requires those who discharge wastewater into California's streams and rivers to submit a report to the Regional Water Quality Control Board. Industries and municipalities have been submitting the waste discharge reports, but all

Letters



Climate debate heats up

Too much space was spent on global warming in the May-June 2002 issue. The editorial points out how little we know about global climate change. The authors also say that global climate change will occur in longer periods than 50 to 100 years. Faced with that uncertainty they propose we should "emphasize measures that reduce the apparent driving forces behind global climate change." The "scientists" pushing the global warming idea never seem to consider factors such as increased output of energy from the sun or subtle changes in the earth's orbit. They concentrate on activities of man as the driving force. The earth has been much colder (glaciers) and warmer than it currently is. Industrial mankind wasn't around for those changes. I suggest we recognize that global climate change occurs but science hasn't yet discovered all of the possible causes and certainly can't interpret the interactions of all the possible causes.

Allan L. James, Mid Valley Ag
Linden, California

Bryan Weare ("Global climate change will affect air, water in California," Cal Ag 56(3):89–96) responds:

The reader states that scientists "never seem to consider factors such as increased output of energy from the sun or subtle changes in the earth's orbit." This is incorrect. The Hadley model, as well as many others, has taken into account our best understanding of solar output changes over the time frame of decades to centuries. Solar orbital changes work only on much longer times of many thousands of years.

Second, the reader notes that the earth's climate has been colder and warmer than it currently is, and that these changes occurred long before industrial mankind. Nothing in the review article suggests that climate change does not exist on longer glacial time scales. However, human activity is apparently leading to relatively large changes in climate at a rate much faster than has been seen in the recent geological past or is likely without human intervention. Of course climate is always changing. The important policy factor is whether or not the rate of change is exceeding our ability to accommodate it without large disruptions in our social and economic institutions.

◀ **A new method developed by UC scientists is helping dairies to better manage their wastewater lagoons. The researchers took measurements of a typical lagoon's oxygen and organic acid content.**

Rapid test helps dairies manage wastewater

UC scientists have developed a system for dairy operators to quickly measure nitrogen in dairy wastewater, giving them an important tool in the complex and environmentally sensitive task of managing wastewater lagoons.

Typically dairy wastewater is pumped from plastic-lined storage areas called lagoons or ponds onto adjacent farmland, where farmers grow corn or winter forage for cow feed. To ensure a good crop, commercial fertilizer is commonly added. But the practice can result in more nitrogen being applied than the crop can use. The leftover can seep down into the aquifer and pollute groundwater.

"A lot of dairy operators don't have the capacity in a wet winter to hold all the water in their ponds," says Thomas Harter, UC Davis groundwater hydrologist. "It is standard practice to empty the pond in the fall. But if the soil is sandy, you can't put fertilizer on during one part of the year and hope it is there 6 months later to help plants grow."

Harter, UC Davis soils specialist Roland Meyer, UC Cooperative Extension farm advisor Marsha Campbell-Mathews and Regional Water Quality Control Board scientist Harley Davis reported in the *Journal of Contaminant Hydrology* this year that shallow groundwater in the vicinity of five Stanislaus County dairies had high levels of nitrate. Forty-four wells were installed at the five dairies and water quality was observed over a 4-year period. The average shallow groundwater nitrate concentration was 64 milligrams per liter, compared to 24 milligrams per liter in shallow wells immediately upgradient of these dairies.

"Data seems to indicate that 80% of the nitrate associated with the groundwater is coming from misapplication of nutrients to the field," Campbell-Mathews says. "Fortunately, we can do something about that."

Campbell-Mathews says careful monitoring of nitrogen in dairy lagoon water and precise application procedures allow dairies to produce a top-yielding crop and reduce the risk of contaminating groundwater. The scientists demonstrated the system at the Clauss Dairy Farm in Stanislaus County. Within 4 years, the nitrate level in shallow groundwater adjacent to the demonstration fields dropped nearly 75%.

The research on groundwater contamination was conducted in a part of the state with sandy soils, which are more likely to allow nitrates to leach into groundwater.

"If we demonstrate significant improvements here in the worst-case scenario, we've developed a system that can protect groundwater quality at dairies throughout the state," Meyer says.

Within 4 years, the nitrate level in shallow groundwater adjacent to the demonstration fields dropped nearly 75%.

The system requires proper equipment, including a rapid ammonia test, flow meter, adequate conduits to the fields and sufficient storage capacity for lagoon water.

Campbell-Mathews worked with Hach Chemical to develop the 4- to 6-minute rapid ammonia test, which substitutes for a laboratory test that can take several days. Farmers can use the rapid test to sample lagoon water without ever leaving the lagoon bank.

Where the system has been implemented, farmers have been pleased with the results. "They are saving about $50 to $70 per acre on fertilizer costs and finding the nutrient management system is not any more hassle than hauling anhydrous ammonia tanks around the farm to apply fertilizer," Campbell-Mathews says.

The researchers have trained about 100 dairy operators on the new lagoon nutrient management system in Stanislaus, Fresno and Tulare counties, and developed a Web site for dairy farmers interested in implementing the system.

Go to: *http://groups.ucanr.org/lnm.*

— *Jeannette Warnert*

Marin ranchers bullish on grass-fed livestock

While demand for grass-fed meats has increased in recent years, current media attention has spurred a flurry of interest that has been a boon for ranchers pursuing this niche market.

"We've been unbelievably busy since March 31, when Michael Pollan's article appeared in the New York Times Magazine," Mike Gale of Chileno Valley Natural Beef told a group of ranchers at a recent meeting hosted by UC Cooperative Extension in Marin County. "We've doubled our production."

The New York Times feature followed a Midwestern steer from birth to slaughter, detailing its feedlot regimen of limited exercise, growth hormones and fattening on corn. Since cattle are ruminants, their digestive systems are not accustomed to grains, making them more prone to disease; as a result, they need regular doses of antibiotics.

Grass-fed livestock, while not necessarily certified as organic, is raised almost entirely on pasture, and cattle usually do not receive hormones or antibiotics. As a result, beef fatten much more slowly. "It's a whole different way of thinking, as a rancher," Gale said.

Beef cattle are still among the top commodities in California, but the industry is facing increasing challenges due to trends such as packer consolidation (see p. 152). Grass-fed meats comprise a miniscule but growing portion of the state market. To assist ranchers who may want to take advantage of this opportunity, Steve Quirt, Marin County's newly hired organic and sustainable agriculture coordinator, convened the Natural and Organic Livestock Workgroup in mid-2002. (A grant from the Marin Community Foundation will help fund the effort.) About 20 ranchers gathered at the June meeting in Novato.

Travis Potter of Prather Ranch, near Mt. Shasta, described the operation's pioneering approach to raising and marketing certified organic beef, veal and other natural meat products. Prather uses diatomaceous earth and organic garlic to reduce parasites, and walnut husks for deworming. The beef is dry-aged for 3 weeks and freeze-frozen and vacuum-packed, then sold primarily directly to consumers at Northern California farmers' markets. "We're selling as much as we can," Potter said.

Quirt said Marin County's grass-fed industry is also working under "a new paradigm of marketing meat directly to consumers." A similar type of local marketing effort is under way in six Sierra Nevada counties, coordinated by UCCE advisors for Plumas-Sierra and Placer counties.

Steve Quirt

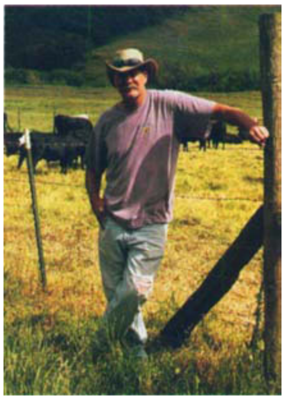
In Marin County, UC Cooperative Extension convened the Natural and Organic Livestock Work Group to help local ranchers explore opportunities for marketing grass-fed meats. Addressing the group, *left to right,* are: Travis Potter, Prather Ranch; Dave Evans, Marin Sun Farms; Mike Gale, Chileno Valley Natural Beef; and Erik Parks, Marin Sun Farms.

A different product

Proponents believe there is evidence that grass-fed beef is less fatty and contains more vitamins and antioxidants than corn-fed, but widespread public acceptance will nonetheless be a major challenge. Grass-fed beef is much more expensive and is generally seasonal, as most ranches slaughter in the late spring. Furthermore, it tastes different than corn-fed beef, and may have fat marbling that is more yellow than white. Erik Parks of Marin Sun Farms said it is leaner and should be prepared differently.

"Because it has smaller muscle fibers, it shrinks much faster," said Parks, a fifth-generation North Coast rancher who graduated from the Culinary Institute in New York. To prevent toughness, he recommends searing grass-fed beef on the outside, then cooking on a lower heat and allowing it to rest before serving.

The Marin County ranchers are hoping to bank on their close proximity to environmentally and health-conscious Bay Area consumers and restaurants, as well as the county's unique and specialized microclimate, with a long, cool, grassland growing season that is ideal for livestock. The UC-sponsored workgroup will study the possibility of forming a Marin County grass-fed meat association and cooperating on a mobile slaughter unit. They would also like to develop local standards for natural, pasture-finished and grass-fed meats, so that consumers understand exactly how the animal was raised.



Mike Gale of Chileno Valley Natural Beef has doubled his business since the media began paying more attention to grass-fed beef.

"Consumers really need to believe that there's something behind these terms," Gale said. "When it all boils down, all we have is our integrity."

For workgroup information, contact Quirt at wsquirt@ucdavis.edu or (415)499-4209; for product information, go to www.eatwild.com. — *Janet Byron*

California's cattle and beef industry at the crossroads

Matt A. Andersen
Steven C. Blank
Tiffany LaMendola
Richard J. Sexton

While cattle and beef are California's fifth most valuable agricultural product, the industry is struggling due to technological change and consolidation. Cattle are rounded up at a California ranch.

Beef cattle remain one of California's most important agricultural products, ranking fifth in 2001 at $1.35 billion in value of production, behind dairy, grapes, nursery products and lettuce. However, technological change, coupled with declining consumption of red meats during the 1970s and 1980s, triggered a wave of mergers and acquisitions in the beef-processing sector. To evaluate how such trends are affecting the industry in California, we undertook a survey during 2000 and 2001 and obtained responses from ranchers in 40 counties. Our results confirm that the industry appears to be at a crossroads, for a variety of reasons. Cow-calf ranching operations now predominate, and a significant percentage of cattle leave the state for feeding and slaughter. Auction yards, a principal marketing outlet for most of the survey respondents, require a large volume of activity in order to operate efficiently. As aging ranchers exit the business, this important exchange mechanism is threatened, possibly contributing to the industry's further decline. Most ranchers reported having five or fewer potential buyers for their cattle.

The cattle and beef sectors in the United States have evolved in rapid and fundamental ways. The "boxed-beef" technology introduced in the 1960s and concurrent advances in shipping technology have enabled carcasses to be processed into individual cuts, packed and shipped nationally or internationally from the same plant where slaughter took place. This capital-intensive technology resulted in expanded economies of scale. Technological change, coupled with declining consumption of red meat during the 1970s and 1980s, triggered a wave of mergers and acquisitions in the beef-processing sector. In 1977, the four leading beef packers were estimated to hold 30% of total U.S. slaughter capacity; by 1999 that share had risen to 82%. Analysts generally agree that this technological change, coupled with the increase in packer concentration, has increased efficiency in the processing sector (Morrison-Paul 2000). However, benefits to producers from enhanced efficiency can be dissipated or eliminated if packers are able to exercise market power as a result of industry consolidation (USDA 1996; Azzam and Schroeter 1997).

Rapid change has also occurred in the marketing arrangements between cattle producers and beef processors. In particular, there is evidence of tighter vertical control, such as packer-fed cattle, producer-packer forward contracts, and marketing agreements between producers and packers wherein cattle are priced according to a predetermined formula. All of these arrangements are lumped under the term "captive supplies" because the cattle are tied *ex ante* to a particular processor, and not sold on the open market.

Empirical evidence from various markets suggests a negative correlation between the use of captive supplies in a region and the cash-market price (Ward 2002). Accordingly, various producer groups, government regulators and academics have expressed concern about the evolution of these marketing arrangements, especially in light of rising packer concentration and reduced selling opportunities for producers. A ban on packer feeding was debated but not included in the Farm Bill that recently passed, and is now being debated by Congress as a stand-alone piece of legislation.

Most of the aforementioned investigation has focused on the major cattle-producing states in the Midwest, and comparatively little attention has been paid to California's cattle industry. However, beef cattle and calves remain one of California's most important agricultural products, ranking fifth (behind dairy, grapes, nursery products and lettuce) in 2001 value of production at $1.35 billion. Cattle and calves were the leading agricultural commodity, based on value of production, for nine California counties: Calaveras, Imperial, Mariposa, Nevada, Plumas, Shasta, Sierra, Trinity and Tuolumne. They are second in importance in six others: Amador, Inyo, Marin, Modoc, Placer and San Bernardino.

Because of its importance to California's agricultural economy and the comparative neglect it has received in the multitude of studies conducted on the U.S. cattle and beef industry (Ward 2002), we undertook an investigation of the status of those industries in California. The main goal was to document the evolution of production and marketing and to obtain a perspective on the impacts of increasing packer concentration and vertical coordination on the California industry.

Cattle production and processing

California's greatest concentrations of cattle are in the Central Valley counties of Fresno, Kern, Merced, Stanislaus and Tulare, and the arid southern region comprised by Imperial, Riverside and San Bernardino counties (fig. 1). Although cattle production is a leading agricultural industry for such northern counties as Modoc, Plumas, Shasta, Sierra and Trinity, production in those counties pales relative to the Central Valley and southern counties.

Fig. 1. Cattle and calves, average inventory levels by county, 1982–1997, and locations of facilities reporting slaughter of cattle and calves, 1997. Sources: California Census of Agriculture; USDA Grain Inspection, Packers and Stockyards Administration.

The major growth has occurred in the Central Valley and desert-south regions, with an additional pocket of growth in North Coast counties such as Del Norte, Humbolt, Mendocino and Trinity (fig. 2). Not surprisingly, cattle production has declined in the counties that represent the major urban growth corridors within the state, particularly the central- and south-coast regions.

In 1997, 10 facilities in California reported slaughter of cattle and calves to the U.S. Department of Agriculture (USDA)(fig. 1). Only three of those process significant numbers of cattle: an IBP plant in Fresno, Harris Ranch in Coalinga and Shamrock Meats in Los Angeles. The others are small specialty operations that do not contribute importantly to the state's processing capacity. By way of contrast, 52 facilities reported slaughter of cattle and calves to USDA in 1972. Due to the rapid decline in its slaughter capacity, California is now a significant net exporter of live cattle for slaughter, with cattle being shipped to plants in locations ranging from Washington to Utah and Colorado. Long-distance shipping of cattle is costly, due both to the transportation costs and stress on the animals, so the necessity of such travel reduces the profitability of cattle production in California.

Producer survey

Only a limited amount of information specific to California cattle production can be gleaned from the standard statistical sources, so we undertook a survey of cattle producers in the state during 2000 and 2001. To facilitate the survey, we cooperated with county-level UC Cooperative Extension livestock advisors. The county personnel contributed to development of the survey and distributed the survey forms, either in-person, at trade shows or through the mail. To further encourage compliance, we kept the survey form short, one double-sided page with 12 categorical or short-answer questions, focusing primarily upon marketing issues.

In total, we received 280 completed surveys. We obtained responses from

TABLE 1. Number of cattle marketed annually by type for survey respondents

	1–50	51–150	151–300	300+	Total
Calves	109	61	36	25	231
Cull cows/bulls	181	25	4	6	216
Yearlings	82	41	20	25	168
Fed cattle	26	7	2	17	52
Total responses	398	134	62	73	

ranchers in 40 of California's 58 counties. Counties with the most respondents were Shasta (66), Stanislaus (58), Merced (58) and Calaveras (34). (A single respondent might operate, and hence be counted, in multiple counties.) We focused the survey on three regions of the state to see if there are geographic differences in industry structure and marketing opportunities. The north region was centered in Lassen, Shasta and Tehama counties. The central region focused on Stanislaus and surrounding counties, while the coastal region included counties ranging from Humboldt to Monterey. In general, our survey results indicate that average ranches in the north and central regions are virtually identical in size, herd composition and marketing strategies. Ranches in the coastal region, on average, are much smaller and more often part-time operations.

Land ownership. The vast majority of respondents (246) owned some of their own ranch land and also rented additional land in either the summer or winter. In particular, 178 rented summer land and 167 rented winter land from private parties, while 38 reported renting summer land and 12 reported renting winter land from the U.S. Bureau of Land Management or Forest Service.

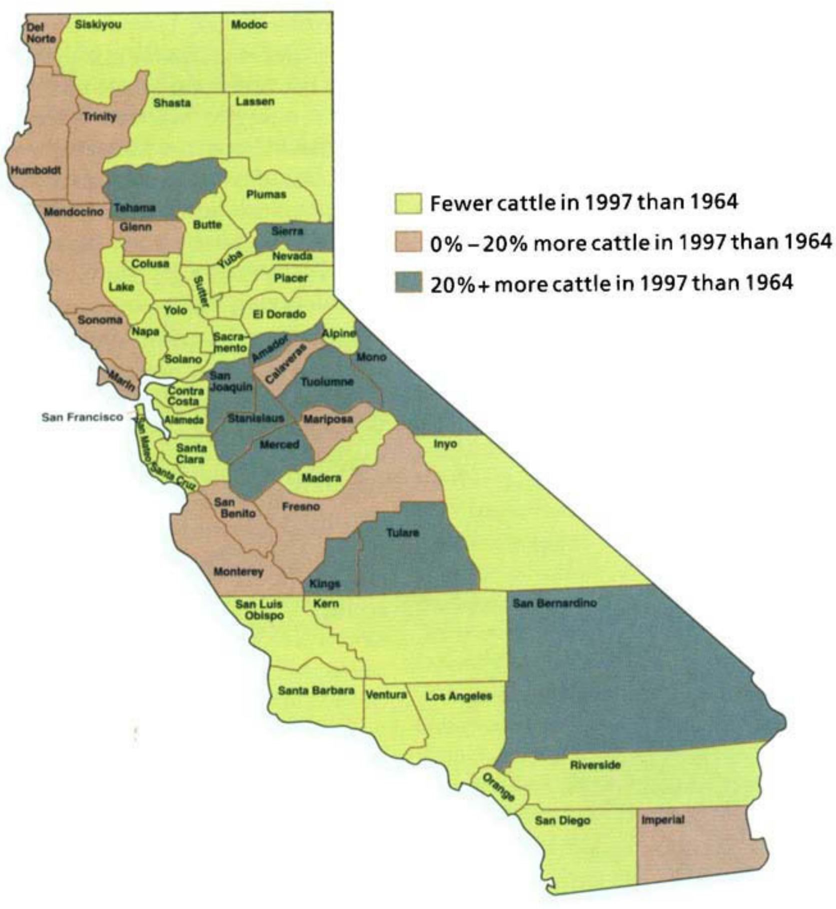


Fig. 2. Cattle and calves (excluding milk cows), percentage change in inventory levels, 1964–1997. Source: California Census of Agriculture.

Ranching experience. The average years of experience in ranching among the survey respondents was 34.9, meaning that ranching has been a lifetime operation for most and that, collectively, they represent a well-seasoned group. Most of the operations are family oriented, so the fact that many operators appear to be nearing retirement age raises questions about continuity of the operations if sons/daughters choose not to carry on the family business.

Cattle sold. We used categories of 1 to 50, 51 to 150, 151 to 300, and more than 300 to inquire about the number of cattle marketed annually by type (table 1). Ranchers in the north, central and coastal regions are primarily cow-calf operators, who specialize in raising and marketing young cattle and cull cows or bulls. In particular, relatively few engage in feedlot operations. Only 16% of respondents in the north, 20% in the central and 8% in the coastal region marketed fed cattle.

The largest category of response for all types of cattle was the 1 to 50 animal category. Such operations represent part-time businesses. In the central and north regions, calves and yearlings are the primary focus, and large operations make up a significant part of the industry. For example, in the central region, 11% of ranches sell more than 300 calves per year, and 12% of ranches sell more than 300 yearlings annually. These operations are clearly full-time business with sizeable assets invested.

Sales mechanisms. We also asked respondents to indicate the selling

Brian Prechtel-USDA/ARS

In a survey covering nearly 300 ranches in 40 counties, the authors found that only 29% of the state's cattle destined for feedlots remained in California, with the rest shipped to the U.S. Northwest, Midwest and Southwest.

mechanism they utilized to market their cattle. The predominant marketing mechanism among the respondents in all regions was the traditional, privately operated auction sale yard, which 240 reported utilizing for at least some sales. Sixty-one ranchers also indicated using an auction operated by a cattle association. One hundred five respondents reported direct sales to local buyers, with 52 reporting direct sales to regional or national buyers. Interestingly, the much-touted "high-tech" selling mechanisms, such as video and electronic auctions, were used infrequently by the respondents — 27 reported using a video auction (none from the coastal region) and only one person reported using an electronic auction.

An important point in considering the marketing tools utilized by California ranchers is that substantial economies of scale exist with respect to some selling mechanisms, including various forms of direct sales and video or electronic auctions. The standard trucks used to haul cattle accommodate, for example, upwards of 50 yearling calves. Ranchers who cannot provide at least this much volume in a sales transaction are at a competitive disadvantage. Private or cattle-association auction yards represent the primary sales outlet for these small-scale producers because buyers can rather easily aggregate small lots from various sellers to attain truck capacity. For example, among the respondents to our survey, 93 marketed more than 150 cattle annually in at least one of the four categories indicated in table 1. Among this group of larger producers, 35 (37.6%) reported sales to regional or national buyers, whereas only 17 (10.2%) of the 167 with sales of 150 cattle or less in any category were able to attract the interest of these buyers. Due to the rising concentration in the industry, it is important for ranchers to be able to access the widest pool of potential buyers possible.

Other marketing tools. Our respondents were reluctant to use futures and/or options contracts, with only 6% reporting use of these marketing tools (none from the coast). Similarly, the much discussed and disputed captive-supply mechanisms were little in evidence among our respondents, with only 8.6% reporting using either forward contracts or marketing agreements. The limited use of these marketing tools is due in part to the fact that California ranchers in most cases are not selling cattle directly to packers, where these mechanisms have been used most widely, and also due to the small scale of many respondents' operations.

Cattle destinations. Most likely due to the limited processing capacity in the state, a large portion of California production nowadays consists of young cattle, which are then sold for fattening elsewhere. This conclusion is supported by responses to a question about the cattle's destination after leaving the producers' ranch. A total of 135 respondents indicated that cattle were headed for further development on grassland, while 205 indicated that cattle were destined for a feedlot. Only 58 reported making sales directly to a packinghouse. (Totals sum to more than the number of survey responses because ranchers may have multiple destinations for their cattle.)

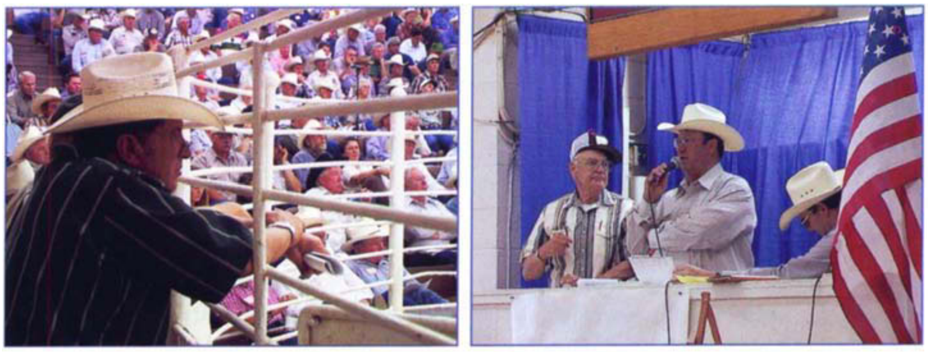
Among the cattle destined for further development on rangeland, 53% were reported to remain in California, with Northwestern states (Idaho, Oregon and Washington) representing the second-most reported destination. Among the cattle destined for feedlots, only 29% remained in California, with 19%, 16% and 12% destined for feedlots in the Northwest, Midwest (Kansas, Nebraska) and Southwest (Arizona, Nevada, New Mexico, Texas), respectively. Nearly 62% of cattle destined for packinghouses remained in California, based upon survey responses.

Potential buyers. Finally, because of the consolidation among firms in the beef sector, we asked about the number of potential buyers available to cattle producers in a given selling environment. The respondents indicated either one, two, three to five, or more than five potential buyers. The modal response (with a total of 115) was three to five buyers. Ninety-eight ranchers (more often from the central region) reported more than five buyers, with 29 reporting only one or two possible buyers. A firm consensus has not emerged among economists as to the number of0 buyers needed to create a competitive selling environment. Most, however, would agree that five or fewer buyers represent an oligopsony market setting, where buyer market power is a potential concern.

Future of California beef industry

While cattle production remains one of California's most important agricultural industries, it is now at a crossroads, for a variety of reasons. As

Photos: Kevin Devine/Shasta Livestock



Concerned about economic trends that are leaving them with a shrinking percentage of the beef dollar, cattle ranchers gathered at the Shasta Livestock Auction in Cottonwood in June to discuss futures contracts, packer concentration and improved cooperation among producers. *Left,* Duane Martin of Clements, Calif., helped organize the meeting. *Right,* Ellington Peek of Shasta Livestock looks on as Ron Anderson moderates.

noted, many operators of these predominantly family-run businesses are nearing retirement age, with uncertain prospects for continuity of the family operations. Moreover, the state's industry now consists predominantly of cow-calf ranching operations, with a significant share of cattle leaving the state for feeding and slaughter. A key factor in explaining the paucity of feeding operations in the state is California's status as a net importer of feed grains such as corn. This status was reinforced through the 1990s when significant acreage in California moved from annual crops such as corn and wheat to perennial tree and vine crops (Blank 2000). Feed grains for cattle are now grown in California primarily as a rotation crop. In practical terms, it is cheaper to incur the one-time expense of hauling the steer to the feed than to continuously haul the feed to the steer.

Because of the expense and risk of shipping fattened cattle long distances, it is economical to locate processing facilities in close proximity to feedlots, helping to explain the exodus of packing facilities from California. The transaction costs associated with out-of-state shipment inevitably place California at a competitive disadvantage relative to states (such as Colorado, Kansas, Nebraska and Texas) and regions (such as the Midwest and Southwest) that combine substantial capacity in production, feeding and processing. Moreover, the lack of local selling alternatives may place California producers in a disadvantageous competitive position in dealings with out-of-state buyers.

The rangeland utilized for cattle production in California often has few alternative uses, except other grazing operations. This fact may explain the resiliency of this segment of the cattle-beef chain, despite the generally poor economic climate for cattle production in recent years, and the mid-1990s in particular, when weak demand and the high-production phase of the cattle cycle caused most producers to lose money. Nonetheless, the long-run viability of these operations requires a stream of revenues that is at least sufficient to compensate for all costs, including opportunity costs for owned land and operator labor. Achieving such revenues will be a challenge if the state continues to operate with cost disadvantages relative to competing states. The auction yards, which provide the principal marketing outlet for most of the survey respondents, require a large volume of activity in order to operate efficiently. If some ranchers exit the business, their departure will impose external costs on those who remain by threatening the vitality of these exchange mechanisms. In turn, if spot-market exchanges wane, ranchers will be compelled to expand or consolidate to attain the selling economies needed to participate in direct sales or other high-tech selling mechanisms.

Furthermore, feedlots and packing plants are not popular enterprises in a populous and environmentally conscious state like California due to odor and waste-disposal issues. However, these operations provide favorable marketing outlets for California's ranch operators and, hence, affect the vitality of the entire cattle-beef sector. The political challenges in gaining approval for such facilities notwithstanding, the economics of these operations favor locating them in regions with extensive feed-grain production, so California is at a cost disadvantage. For a variety of reasons, there is little chance that these operations will expand in California and they may well continue to decline. California cattle ranchers must continue to search for marketing innovations that will enable them to compete effectively in a challenging environment.

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Survey quantifies cost of organic milk production in California

Leslie J. Butler

This study measures the cost of organic milk production, and in particular, the differences in cost of production between organic and conventional milk in California. Results show that the total cost of production on a per cow and a per hundredweight basis is about 10% higher for organic producers than for conventional producers in the surveyed regions, and about 20% higher when compared on a statewide basis. The higher costs appear to be due to reduced milk production, higher feed costs, higher average labor costs, significantly higher herd replacement costs and significant transition costs. The higher costs associated with organic milk production are exacerbated to some extent by lower milk yields, and at the same time, are mitigated by the substitution of lower cost pasture for higher priced roughage and concentrate feeds. The higher prices paid for organic milk may more than offset these higher costs compared to their regional, same-sized neighbors.

Alfred Benjamin

The number of cows raised organically increased sharply during the 1990s, but still represents a very small portion of the dairy industry. Organic dairies rely on ecologically based practices such as pasture feeding, *above*, at Straus Family Creamery in Marin County. (This photograph and those on the following pages show a sampling of organic dairies in California; these dairies did not necessarily participate in the author's survey.)

Organic farming was one of the fastest growing segments of U.S. agriculture during the 1990s (Greene 2000). The number of organic farmers in the United States has been increasing by 12% per year, and organic agriculture has grown from $78 million in 1980 to about $8 billion today, with projected growth of about 20% a year (Greene 2000). According to studies by the U.S. Department of Agriculture (USDA) Economic Research Service, two organic livestock sectors — eggs and dairy — grew even faster. From 1992 to 1997, the number of registered organic dairy cows increased sharply from 2,265 in 1992 to 12,897 in 1997. Preliminary estimates for 2001 put organic cow numbers near 20,000.

If the demand for organic milk and dairy products continues to increase at the pace it has in the past, more conventional dairy producers are likely to consider switching to organic milk production (Dimitri and Richman 2000). The higher prices paid for organic milk are often very attractive for the dairy producer with a smaller herd (Dobbs 1998).

The main goal of this study is to determine the cost of organic milk production in California, and in particular, the differences in production costs between organic and conventional milk, in order to provide information for conventional California dairy producers who might be interested in or considering switching to organic. Much of the difference in cost occurs because of the differences in the management of organic milk cows, many of which are mandatory.

In 1990, the U.S. Congress passed the Organic Foods Production Act to establish national standards for organically produced commodities. Organic farming systems rely on ecologically based practices such as cultural and biological pest management. They exclude the use of synthetic chemicals in crops and prohibit the use of antibiotics and hormones in livestock. Organic livestock production systems attempt to accommodate an animal's natural nutritional and behavioral requirements. Livestock standards address the origin of each animal and incorporate requirements for living conditions, access to the outdoors, feed ration and health care practices suitable to the needs of particular species.

Organic dairying in California

Organic standards in most states are stricter than the rules issued under the 1990 federal act (Duram 1998). In California, organic milk production must conform to the California Organic Foods Production Act (1990), which stipulates — among other things — that producers feed 100% certified organic feed to livestock, not use antibiotics, hormones or prophylactic medications of any kind, and avoid artificial rumen stimulants (see box).

To be approved under USDA's new organic standards, which will be enforced in October 2002, milk must be 100% under continuous organic management for 1 year prior to delivery. Cows producing organic milk must be fed 100% organic feed, and there is zero tolerance for antibiotics. Parasiticides also cannot be used on a regular basis and require 90-day withdrawal times. No genetically modified organisms (GMOs) or their derivatives are allowed, including chymosin (used in cheese making) and recombinant bovine somatotropin (rbST). In addition, cows must have access to pasture.

In 1999, there were about 10 organic dairy producers in California, each with an average of about 200 cows. Milk production per cow varied considerably among organic producers, but appeared to average about 18,000 pounds. This was about 15% less than the 1999 average California conventional production of almost 21,000 pounds per cow. Total production of organic milk in California in 1999 was about 36 million pounds, which was approximately 0.12% of the state's total. However, about 90% of the organic milk produced is used for Class 1, or fluid, purposes. Therefore, organic milk constitutes about 0.5% of the total fluid milk market in California.

Conventional vs. organic dairying

Converting from conventional to organic production is a long-term commitment that needs to be carefully planned and executed to avoid the financial stress that can occur during the transition period. This is particularly true in California where dairying is characterized by large herds, dry-lot intensive feeding of mainly purchased feeds and the use of alternative feeds. The fact that California dairy producers rely on mostly purchased feeds and grow very little of their own (apart from pasture in some regions), means that organic producers must find sources of organic supplemental feed that satisfy the standards. These feeds often cost 25% to 50% more than conventional feeds. However, organic producers rely much more heavily on feeding pasture, and may experience lower milk yields.

Since organic milk producers are prohibited from using drugs, prophylactic medication and growth stimulants or regulators, they are strongly motivated to prevent ailments in the first place, avoiding the complications

California organic rules for dairy

- **Under the original California Organic Foods Production Act, all feeds administered to livestock within 1 year of taking milk must be 100% certified organic. This was amended in 1998 to stipulate that in the first 10 months prior to the taking of milk, 80% of any feed must be organic, and in the final 2 months, 100% must be organic. This regulation will remain in effect until implementation of the federal program in October 2002.**
- **Organic dairies are prohibited from using any drug, medication, hormone or growth regulator — synthetic or otherwise — and any synthetic substance including growth or milk stimulants and antibiotics. (The exception is that if a licensed veterinarian prescribes a drug or medication for a sick cow, the withdrawal period is 30 days or twice the FDA specified time, whichever is longer.)**
- **Artificial rumen stimulants such as plastic pellets, and any fed or refed manure are also prohibited.**
- **All organic milk producers must be registered with the California Organic Program, administered by CDFA. When the federal program is enacted, certification by a USDA-accredited certifying agency will be mandatory.**
- **All feeds grown for the purpose of feeding cows for organic milk production (including pastures) must also meet all criteria of the California Food and Agricultural Code for organic production.**

Cal Ag graphics

Organic dairy products, including milk, cheese, butter, sour cream and yogurt, are available in many California supermarkets and grocery stores.

TABLE 1. Basic cost comparisons for conventional and organic dairies, 1999

	Conventional	Organic	Ratio
Yearly cull rate (%)	29%	25%	0.86
Milk cow hay price ($/ton)	$135.20	$147.50	1.09a*
Price of concentrates ($/ton)	$156.94	$210.07	1.34c
Concentrates fed (lb/cow/day)	25.05	16.24	0.65c
Milk sold (lb/milk cow/day)	61.66	53.78	0.87a

* One-tailed *t*-test significance: a = 10% level, b = 5% level, c = 1% level.

TABLE 2. Feed costs, 1999

	Conventional	Organic	Conventional	Organic
	....*Per cow per month ($)*....		..........*Per cwt.($)**..........	
Dry roughage	31.29	35.44	1.98	2.24
Wet roughage	14.30	14.07	0.89	0.80
Concentrates	51.55	48.70	3.24	3.09
Pasture	2.10	6.66a†	0.14	0.45a
Total feed costs	**99.25**	**104.87**	**6.25**	**6.57**

* Hundredweight.
† One-tailed *t*-test significance: a = 10% level, b = 5% level, c = 1% level.

of sick or ailing cows. Should cows become sick, organic producers use natural medications such as aspirin, garlic and echinacea. Organic producers often scale back milk production, trying not to push the cows as hard as conventional producers might to maximize milk production. As one producer put it, "Cows are like cars. If you push them too hard, they break." Organic producers also attempt to maintain high standards of comfort to provide a better environment for their cows so that the possibilities of ailments like subclinical mastitis are reduced. This may however lead to slightly higher operating costs.

Since cows entering an organic dairy herd must be fed organic feeds at least 1 year prior to the taking of milk, most organic producers find it necessary to raise their own replacements organically, or to purchase organically raised cows. This often adds an additional 10% to 20% to replacement costs.

The 1-year transition period needed to convert to organic is also a significant cost. During this period, organic producers are producing organic milk, but it can only be sold as conventional milk. The costs associated with this transition can only be recovered after the dairy has been certified organic.

Organic dairy producers are usually certified by an accredited certifying agency. In California, the certifying costs can run anywhere from $2,000 to $3,500 annually. Organic dairy producers may also incur higher transportation costs, primarily because the few that exist are spread out over a large area, as well as other small-market access costs.

With a planned reduction in milk production per cow, and assuming feed costs are about 50% of total costs, herd replacement about 15%, and operating costs about 12%, we might conservatively estimate that these additional costs would add about 15% to 20% to the total costs of an organic dairy relative to a conventional operation.

Survey of organic dairies

We identified six organic milk producers who were willing to share their cost of production data for 1999. Three producers were located north of San Francisco in Marin, Sonoma and Mendocino counties (North Bay). The other three producers were located in the northern Central Valley in Stanislaus and Merced counties (North Valley).

A major challenge in this type of research is finding comparable data from organic and conventional producers. Fortunately, the California Department of Food and Agriculture (CDFA) conducts a comprehensive dairy cost production survey, which involves about 400 dairy enterprises in the state's five major producing regions. (CDFA currently does not survey organic dairies.) Each dairy is visited every 2 months, and the data is summarized in the form of costs per cow per month, or costs per hundredweight of milk per month. In this study, we use the 1999 feedback reports, which consist of bimonthly observations of the monthly costs associated with producing milk at each surveyed dairy. Since the organic farms were located in only two of the state's five production regions, we used the feedback reports from those two regions (North Bay and North Valley), and specifically used only the data pertaining to the comparable herd sizes in each region for 1999. Our comparative data set then includes seven dairies from the North Bay, and 20 enterprises from the North Valley. The data from the two regions was combined, annualized and summarized in monthly format. As with other studies of this nature, the small sample size of organic dairies (6) increases the influence of individual operator variability, a factor that is more effectively obscured in the larger conventional dairy sample (27).

The survey of organic dairies followed the format of the CDFA survey as closely as possible to make them as comparable as possible. However, there are differences in the way the surveys were conducted. First, the CDFA survey is conducted bimonthly for each dairy, and the data is reported as monthly costs. In contrast, our survey of organic dairies was carried out only once. Where possible, monthly costs and production statistics were recorded, but some data was only available on an annual basis and converted to monthly data for comparison purposes. Second, we were not able to identify each individual farm included in the CDFA survey, for confidentiality purposes. Therefore the CDFA data does not allow us to annualize each individual farm and perform detailed statistical comparisons between conventional and organic farms. Third, certain data collected and reported by CDFA differed from the data collected from organic enterprises because CDFA uses a number of averaging factors to harmonize their data. For example, labor wage costs collected by CDFA use an average hourly rate for all hired employees in the cost of production area. Interest expenses include a standardized feed inventory and are calculated using an average current rate paid on agricultural loans. Taxes and insurance expenses on owned real and personal property used in the dairy operation are assumed to be the same for all enterprises in a production region. Blend prices received for milk are based on the California Pool Price announcement for the month, and do not include quality or yield bonuses.

TABLE 3. Costs of production, 1999

	Per cow per month		Per cwt.*	
	Conventional	Organic	Conventional	Organic
	$			
Feed costs	99.25	104.87	6.25	6.57
Labor	27.66	31.05	1.78	1.95
Herd replacement	22.94	28.41a†	1.44	1.87b
Operating costs	32.39	32.79	2.05	2.14
Interest expenses	20.30	11.57b	1.29	0.75b
Depreciation	6.53	10.95c	0.41	0.68c
Taxes and insurance	1.40	3.60c	0.09	0.24c
Less – misc. income	−3.72	−3.27	−0.24	−0.21
Transition costs	0.00	5.34	0.00	0.20
Total costs per cow	**206.74**	**225.32**	**13.07**	**14.19a**

* Hundredweight.

† One-tailed *t*-test significance: a = 10% level, b = 5% level, c = 1% level. Additional income derived from the sale of drop calves and the sale of manure, reported as part of the costs of production in order to comply with the way in which CDFA reports their statistics (used here for comparison).

Costs of production

Feed. Organic producers must pay significantly higher prices for alfalfa hay and concentrates than conventional producers (table 1). The higher prices paid for organic feed, however, do not necessarily translate into significantly higher feed costs, although they clearly have an influence (table 2). Total feed costs for organic producers are only 5% to 6% higher than for conventional producers, and are not statistically significant, despite the fact that the price of organic hay and organic concentrates are significantly higher. The only statistically significant difference between organic and conventional feed costs occurs in the cost of pasture.

There are several reasons for this. First, while organic hay and concentrate prices are much higher (9% and 34%, respectively), organic producers rely much more on pasture than on purchased feeds. This would account for the statistically significant differences in the costs of pasture. Second, organic producers also appear to feed significantly smaller amounts of concentrates (64%) than do conventional producers (table 1). To reduce the cost of producing organic milk, organic producers rely mostly on substituting pasture for high-priced purchased roughages and concentrate supplemental feeds.

We also found a significant difference between feed costs in the North Bay compared to those in the North Valley. Irrigated pastures in the North Valley allow organic producers to graze cows for 8 to 9 months of the year, while North Bay nonirrigated pastures last only about 4 months.

Labor. Labor costs are expected to be slightly higher in organic operations. For example, human labor is required to hand-weed pastures for thistles and other noxious weeds, since organic producers are prohibited from using herbicides in their fields. However, labor costs for organic dairies in our survey were rather disparate. About half had higher than normal labor costs because they simply paid higher wages. The other half had lower than normal costs because they were small, family-run enterprises that did not engage much additional labor.

Herd replacement. Herd replacement costs are significantly higher for organic producers because replacement heifers must be raised organically, or must be purchased from specialized organic heifer breeders. Our survey results show that replacement costs increase by about 24% on a per cow basis and 30% on a per hundredweight basis (table 3). However, there is some evidence that these increased costs are offset somewhat by the fact that organic producers have a lower rate of culling and replacement. Organic producers do not push their cows as hard to maximize milk production, so their cows remain in the herd longer.

Operating costs. Operating costs include utilities, supplies, veterinary services, repairs and maintenance, hired services and tractors. While some organic operating costs are higher because of a focus on cow comfort, among other things, some costs are also lower. Veterinary and medicine costs, for example, are much lower, while many other operating expenses are about the same. Overall, operating costs on organic and conventional dairies are about the same.

Interest, taxes and insurance. Interestingly, interest expenses on all agricultural loans for organic producers are almost half that for conventional producers. This may be an anomaly in the survey results and some of the difference can be explained by the way CDFA measures these costs.

Conversely, taxes and insurance expenses for organic producers are more than double those of conventional producers. This difference may be explained by a number of factors. The reported tax and insurance expenses for conventional producers may be lower because of the way they are calculated. In the CDFA feedback reports used to calculate the costs of conventional dairying, tax and insurance expenses are reported at a constant $1.88 per cow per month for the North Bay and $1.23 per cow per month for the North Valley, regardless of the size of the enterprise or facilities, or any of a number of other factors. By contrast, tax and insurance expenses reported in the results of the organic survey are actual expenses, and vary from enterprise to enterprise.

Transition to organic. Although we inquired about transition costs to

Photos: McAfee Farms

In this survey, production costs for California organic dairies were about 10% higher, while net farm income was about twice that of conventional dairies. Organic Pastures Dairy, near Fresno, uses a Grade A mobile milking parlor, *upper left and right,* which moves to the grazing cows for milking, allowing them to be on green pasture at all times. *Left,* The dairy also bottles its own milk.

switch from conventional to certified organic production, most organic producers did not specifically account for these costs. To estimate these costs, we assumed that each dairy incurred the same costs as an organic dairy, but received only the conventional price for their milk. We assumed that the cash costs associated with transition from conventional to organic were exactly the same as borrowing the difference in net farm income from a bank, and repaying the loan at 10% interest over a period of 6 years. (Most financial institutions contacted about these rates specified loans ranging from 3 to 8 years, at interest rates ranging from 8% to 12%.) The estimated average cost associated with transition in 1999 was $288.25 per cow, or about $0.92 per hundredweight of milk. Amortized over a 6-year period at 10%, the cost is $5.34 per cow per month, or about $0.20 per hundredweight. These costs are therefore added into the calculations of total costs (table 3) and for the net farm income calculations below.

In summary, our results found that the total cost of production on a per cow or a per hundredweight basis is about 10% higher for organic producers than for conventional producers. This difference is statistically significant, although the degree of significance varies by particular cost item. Overall, the cost differences appear to be due to reduced milk production, slightly higher feed costs, slightly higher average labor costs, significantly higher herd replacement costs and significant transition costs.

Net farm income

Net farm income (gross revenues minus total costs of production) for organic farms was more than twice that for conventional dairies on both per hundredweight basis and per cow basis in 1999 (table 4), mostly because of the higher prices paid to organic producers for their milk. Organic producers are paid a fixed price per hundredweight for organic milk and the price does not vary monthly. These prices are determined by the organic creameries that purchase the milk. In contrast, conventional producers are paid a blend price, determined by national markets for butter and cheese, which varies, sometimes dramatically, each month. In previous years, such as 1998, when average blend prices paid for conventional milk were higher, these differences in net farm income would not be as dramatic. In 1999, average blend prices for milk in California were slightly higher than the average for the 8-year period from 1994 to 2001.

Marketing costs for organic producers are much higher because of transportation costs and additional annual costs associated with organic certification. In addition, organic milk yields are lower. These two factors bring gross income (or net receipts) per cow much closer together for the two groups (net receipts per cow are only 16% higher for organic producers than for conventional), emphasizing the fact that the higher prices paid to organic milk producers may be justified on the basis of organic milk supply.

Statewide comparison of costs

Even though the sample of organic farms in the survey is concentrated in the North Bay and North Valley, there

TABLE 4. Net farm income per month, 1999

	Conventional	Organic	Ratio
Ave. blend price per cwt.*	$14.16	$18.03	1.27c†
Less marketing costs/cwt.	$0.51	$1.50	2.97c
= Net price per cwt.	$13.65	$16.53	1.21c
Times cwt. of milk sold	16.06	15.27	0.95
= Net receipts per cow	$219.22	$252.41	1.12a
Less total cost per cow	$206.74	$225.32	1.09
= Net income per cow	$12.48	$27.09	2.34a
Divided by cwt. of milk sold	16.06	15.27	0.95
= Net income per cwt.	$0.77	$1.77	2.47b

* Hundredweight.
† One-tailed *t*-test significance: a = 10% level, b = 5% level, c = 1% level.

Jack Kelly Clark

Conventional dairy producers who are considering a transition to organic should take into account important factors such as higher production and feed costs, lowered veterinary and health care costs, and the premium prices they are likely to receive.

are several reasons why it may be appropriate to compare their costs with statewide average costs of milk production. First, organic dairying is practiced in areas of California other than the two areas from which the survey sample was drawn. Because of the differences in costs and management, organic dairying is not necessarily subject to the same regional influences that are characteristic of conventional dairying. Second, when costs of production are used in determining appropriate minimum prices for various classes of conventionally produced milk, the figures used are statewide average costs.

The costs of organic milk production are about 20% higher than average statewide cost of conventional milk production on a per cow basis, and 23% higher on a per hundredweight basis. Labor costs, interest expenses and depreciation costs for statewide conventional milk production are lower than those estimated from the regional feedback reports, while herd replacement costs and operating costs on a per cow basis are higher.

A comparison of net farm income between organic and conventional dairies using statewide average costs shows that, despite the higher prices paid for organic milk, average net farm income is lower for organic production than for conventional milk. Net farm income for organic production on a per cow basis is 75% that of average statewide conventional milk production, and 84% on a net income per hundredweight basis.

Converting to organic production

Organic milk production in California is a very small but rapidly growing segment of the dairy industry. Depending on the continued demand for organic milk and dairy products, organic milk production offers a viable alternative to smaller producers who cannot, or do not wish to compete in the conventional milk market on the basis of economies of size. For the producer contemplating a switch, there are several factors that should be taken into consideration.

First, almost all of the higher costs associated with organic milk production appear to be due to the mandatory rules that circumscribe organic milk production. The most important of these higher costs is the cost of feed, which usually comprises about half of the total costs of milk production. Organic supplementary feeds usually cost 25% to 50% more than conventional feeds. However, most organic dairy producers have managed to overcome what would otherwise be prohibitively higher feed costs by substituting pasture as the main feed.

Second, however, the lower milk yields experienced by feeding pasture have two complementary advantages, apart from lower feed costs. One is that the cows are not pushed to maximize milk production, and therefore tend to remain healthier than their conventional cousins. Another advantage is that the cows tend to remain productive for a longer period of time, reducing the need to cull and replace at the same pace that conventional dairy operations do. This in turn reduces herd replacement costs.

Third, other mandatory items that increase the costs of organic dairying such as certification and licensing costs, small-market transportation costs, and the opportunity costs associated with not being able to use conventional medicines on sick or ailing cows, are relatively small in the whole scheme of total costs. However, it should be recognized that these costs do add up and contribute to the overall increased costs of organic dairying. Transition costs are mandatory and they are significant, although for most producers the amortized loan amounts to only 2% to 3% of total annual costs for about 6 years.

Finally, despite the higher costs and lower milk yield, the higher, fixed price per hundredweight that is paid for organic milk does allow organic dairy producers to increase profitability compared to their same-size, regional neighbors, but does not necessarily increase the overall profitability of milk production compared to the statewide average dairy producer.

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Insecticide choice for alfalfa may protect water quality

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Barbara Reed

Some insecticides used for controlling Egyptian alfalfa weevil have been detected in California's surface waters and are of concern, due to their impact on water quality and toxicity to some aquatic life. To assess the impact of insecticide choice on water quality, we collected tail-water samples from on-farm alfalfa sites in the northern Sacramento Valley over a 3-year period. Samples were collected during irrigation after organophosphate and pyrethroid sprays were applied. We found significant differences between insecticide classes in the mortality of Ceriodaphnia dubia *(water flea), a test organism used to detect pesticides in water. Nearly all sites where organophosphate insecticides were used resulted in 100% water flea mortality in a 24-hour test of tail-water samples; pyrethroid-treated sections of the same fields exhibited insignificant flea mortality. The pyrethroids we used provided significantly better control of Egyptian alfalfa weevil than the organophosphates, with no significant differences in beneficial insect counts. Although water runoff does not always occur in alfalfa fields, insecticide choice may be an important tool for protecting water quality. In addition, consideration should be given to the fact that pyrethroids, while they proved advantageous in these experiments, can affect beneficial species and do have high toxicity to fish at extremely low concentrations.*

To investigate the potential movement of organophosphate and pyrethroid insecticides from alfalfa fields, the authors sampled inflows and outflows on alfalfa farms in the northern Sacramento Valley. UC Davis graduate student Corin Pease collects irrigation source water.

Alfalfa is grown on over 1 million acres in California. With an annual value of $873 million in 2001, it ranks as one of the state's top field crops in gross revenue. Alfalfa is primarily used as high-quality feed for dairies, the state's number one agricultural enterprise at about $4.6 billion in 2001. Fields are harvested 6 to 8 times a year in the Central Valley, which produces more than 60% of the state's crop. In this region fields are typically flood irrigated with 4 to 6 inches of water between harvests.

The major insect pest of alfalfa in California is the Egyptian alfalfa weevil *(Hypera brunneipennis)*. The larvae feed on foliage, causing yield and quality losses to the first and sometimes second hay harvests. The most common strategy for Egyptian alfalfa weevil control involves spraying fields once or twice each spring. Insecticides currently used in California for weevil control include the organophosphates (OP) chlorpyrifos (Lorsban and Lock-On), phosmet (Imidan), malathion (Malathion) and dimethoate (Cygon); the pyrethroids permethrin (Ambush), lambda-cyhalothrin (Warrior) and cyfluthrin (Baythroid); and the carbamate carbofuran (Furadan) (Summers and Godfrey 2001). An average of 708,600 pounds of these insecticides was applied to about 1 million acres of California alfalfa annually from 1998 through 2000, with multiple applications on some fields (DPR 2002). The majority of these applications were made for weevil and aphid control in late winter/early spring, with a smaller number of applications to control various worms during the summer. The use of organophosphates predominated; chlorpyrifos, phosmet, malathion and dimethoate accounted for an average of 87% of the mass (weight) of total insecticides applied and 64% of the insecticide applications to alfalfa statewide from 1998 through 2000. Carbofuran accounted for 9% of the mass applied and 9% of the applications, and the pyrethroids permethrin, lambda-cyhalothrin and cyfluthrin accounted for 4% of the mass applied and 27% of the applications in the same period (DPR 2002).

TABLE 1. Properties of insecticides used to control insect pests in alfalfa

Common name	Trade name	K_{oc}*	Aqueous solubility†	LC_{50}‡
			ppb (µg/L)	
Lambda-cyhalothrin	Warrior	180,000	5	0.3
Cyfluthrin	Baythroid	100,000	2	.14
Chlorpyrifos	Lorsban, Lock-On	6,070	1,180	0.08
Malathion	Malathion	1,800	130,000	1.14
Permethrin	Ambush	100,000	6	0.55
Phosmet	Imidan	820	20,000	1,034
Dimethoate	Cygon	20	39,800,000	1,219

Source: USDA 2002; PAN 2002.

* Soil adsorption coefficient.

† Amount of active ingredient that dissolves in a given volume of water.

‡ Concentration resulting in mortality to 50% of a test population of water fleas (*Ceriodaphnia dubia*) (or *Daphnia magna* for phosmet and dimethoate).

Water quality concerns

Irrigation and storm-water runoff from agriculture, including alfalfa, have been implicated as contributing to the presence of chlorpyrifos, malathion and carbofuran in California surface waters at levels that cause mortality to the water flea *Ceriodaphnia dubia* (SWRCB 2002; deVlaming et al. 2000; Foe and Sheipline 1993). The detection of these insecticides has caused several waterways to be classified as failing to meet water quality standards, as defined by the U.S. Environmental Protection Agency and the State Water Resources Control Board (SWRCB). Section 303(d) of the federal Clean Water Act mandates that total maximum daily load (TMDL) restrictions be developed to improve water quality in affected waterways. A TMDL is the maximum quantity of a pollutant that can enter a water body without adversely affecting beneficial uses. The TMDLs for chlorpyrifos, malathion and carbofuran must be established between 2005 and 2011 for the Central Valley (Region 5), depending on the waterway.

Keith Weller-USDA/ARS

Alfalfa, one of California's top field crops, is used primarily as feed for the state's dairy industry. The federal Clean Water Act will require Central Valley growers, including alfalfa farmers, to limit insecticide pollution in waterways in coming years.

Regulatory implications. An agreement between the California Department of Pesticide Regulation (DPR) and the SWRCB outlines a four-stage process for protecting water quality (see page 148). The first step involves voluntary grower efforts to reduce off-site movement of an insecticide, while later steps require further restrictions or regulation by DPR or the regional water quality boards. At this writing, regulators were encouraging voluntary steps to reduce the presence of these compounds in natural waterways. However, further restrictions and regulations may be forthcoming for some insecticides such as chlorpyrifos.

Alfalfa management limitations. There are few nonchemical management practices available to control Egyptian alfalfa weevil. While early harvest can reduce feeding damage, this option is often not economically viable or is restricted by spring rains. Beneficial insects such as parasitic wasps are natural weevil enemies but generally do not provide sufficient control. Although modern alfalfa varieties are resistant to many pests, a cultivar has yet to be developed that is resistant to the Egyptian alfalfa weevil (Summers 1998). Planting other forages such as berseem clover or oats into established alfalfa mitigates weevil damage, but is limited by market acceptance and management constraints.

Most growers continue to use insecticides for compelling economic reasons. However, all insecticides do not present the same risks to the environment, nor do all insecticide-treated fields affect natural waterways. Insecticides differ in properties such as solubility, adherence to soil particles and toxicity to aquatic invertebrates (table 1). Therefore, certain classes of insecticides may be better suited to prevent off-site pesticide movement from farms where irrigation water drains into natural waterways.

Measuring water quality. Aquatic biologists commonly use *C. dubia* as a test organism to help characterize the risk of toxins to aquatic invertebrates (deVlaming and Norberg-King 1999). Although the use of this invertebrate as the key predictor of the environmental impact of pesticides has been the subject of debate, it continues to be used to detect pesticides in water due to its extreme sensitivity to toxins present at very low (parts per billion [ppb]) concentrations (table 1).

The objective of this study was to evaluate the insect control efficacy of organophosphates and pyrethroids, as well as their effect on the mortality of

C. dubia in tail-water samples obtained from alfalfa production fields.

Field studies

Commercial alfalfa fields (22 in 1999, 9 in 2000 and 10 in 2001) were selected as study sites in the northern Sacramento Valley (table 2). In 1999 and 2000, nearly all fields were divided into two distinct test areas: one received an organophosphate insecticide for weevil control and the other received a pyrethroid treatment. Each test area was a 20- to 60-acre block and each farm was considered a replication. In 2001, monitoring was restricted to seven alfalfa fields treated with lambda-cyhalothrin (a pyrethroid) at labeled rates.

Each year, all fields were treated with insecticides once in the late winter/early spring when weevils reached economic threshold levels of 15 to 20 larvae per sweep, or when significant damage to the alfalfa was observed (Summers and Godfrey 2001). Application dates ranged from March 10 to April 9 in all 3 years. Insecticides were applied by air or ground at 10 to 15 gallons per acre within each field. There was a range of days between application and water runoff sampling, due to irrigation differences.

Toxicity testing. Water samples were collected from each test area using standard methods employed by the UC Davis Aquatic Toxicology Laboratory (Emanuel and Cabugao 2000). We collected 2 gallons of unfiltered water from the head irrigation ditch as water entered the alfalfa fields (source water) and 2 gallons from the end of the field as the water flowed off (tail water). All sites had one to several locations where water exited the fields. Toxicity testing occurred within 48 hours of collection. In 1999 and 2000, all water samples were collected from the first irrigation of the year, which occurred 22 to 62 days after the fields were sprayed. During our study, in 1999 there were 10 rainfall events with a total of 2.7 inches; in 2000, 8 events with 2.8 inches; and in 2001, 7 events with 1.5 inches. Rainfall was not sufficient to cause runoff from the treatment fields. Tests for mortality of *C. dubia* were done according to standardized 24-hour and 96-hour toxicity testing procedures.

Dilution tests. During both 1999 and 2000, all field samples that resulted in 100% mortality within 24 hours were resampled and diluted with varying amounts of control water. A dilution series was created with concentrations of 50%, 25%, 12.5%, 6.25%, 3.12%, 1.56% and 0.78% by volume of the original tail-water sample. These dilutions were then subdivided to create two sample sets, in addition to laboratory water as a control. In one set, we added piperonyl butoxide (PBO) at 100 ppb (µg/L), which inhibits the toxicity of metabolically activated organophosphate insecticides such as chlorpyrifos (Bailey et al. 1996). If the addition of PBO renders a toxic sample nontoxic, organophosphate insecticides are indicated as a likely source of *C. dubia* mortality. The other set of serial dilutions was used to determine the dilution necessary to render the original field sample nontoxic.

Chemical analyses of pyrethroids. In 2001, chemical analyses were performed on tail-water samples from the alfalfa study fields treated with lambda-cyhalothrin to confirm the apparently negligible transport of the insecticide in irrigation runoff indicated by our mortality tests. One-liter samples were collected from the source water, and replicate 0.5-liter samples were collected from the tail water. Five sites were sampled during the first irrigation, 41 to 53 days after the alfalfa fields were sprayed for wee-

TABLE 2. Alfalfa insecticide treatment comparisons for field studies conducted in the northern Sacramento Valley, 1999–2001

Field site†	Year	Treatments* Organophosphate‡ (rate)	Treatments* Pyrethroid§ (rate)	Days from application to sampling
		lb ai/acre		
1	1999	CHLOR (0.5)	LCYH (0.025)	29–34
3	1999	CHLOR (0.5)	LCYH (0.025)	44–46
6¶	1999	CHLOR (0.5)	LCYH (0.025)	31–36
7	1999	CHLOR (0.75)	LCYH (0.025)	48–53
8	1999	CHLOR (0.75)	LCYH (0.025)	32–33
9	1999	CHLOR (0.75)	LCYH (0.025)	34–45
10	1999	CHLOR (0.5) + LCYH (0.02)	CYF (0.044)	38–41
11	1999	CHLOR (0.5) + PERM (0.08)	LCYH (0.025)	35–39
12#	1999	CHLOR (0.5) + PERM (0.1)	LCYH (0.025)	43
15	1999	CHLOR (0.38) + PERM (0.16)	CYF (0.044)	32–33
16	1999	CHLOR (0.5)	LCYH (0.025)	26–29
17¶	1999	CHLOR (0.5)	LCYH (0.025)	59–62
18	1999	CHLOR (0.25) + MAL (1.5)	LCYH (0.025)	28–33
20	1999	CHLOR (0.5) + PERM (0.1)	CYF (0.044)	36–40
22	1999	CHLOR (0.5)	LCYH (0.025)	40–43
23¶	2000	DIMETH (0.33) + PHOS (0.7)	CYF (0.044)	22–23
24	2000	CHLOR (0.5)	LCYH (0.025)	25–27
25	2000	CHLOR (0.5)	CYF (0.038)	26–29
26	2000	CHLOR (0.5 pt) + MAL (1.25)	LCYH (0.03)	27–28
27	2000	PHOS (0.7)	CYF (0.044)	40
29–30**	2000	—	CYF (0.044)	26–44
31**	2000	—	LCYH (0.028)	31
32–41**	2001	—	LCYH (0.025–0.03)	41–62

* Material applied by ground or air at 10–15 gal/acre. Rate is lb ai/acre.

† Site 2, no weevil treatment; sites 4, 5, 14, application change; sites 13, 19, no water runoff; site 21, field source-water contamination; site 28, no confirmation of OP mortality.

‡ CHLOR = chlorpyrifos (Lorsban, Lock-On), MAL = malathion, PHOS = phosmet (Imidan), DIMETH = dimethoate (Cygon).

§ CYF = cyfluthrin (Baythroid), LCYH = lambda-cyhalothrin (Warrior), PERM = permethrin (Ambush).

¶ Pyrethroid data contaminated with OP insecticide.

\# Pyrethroid data lost through inability to obtain water sample.

**No paired treatments.

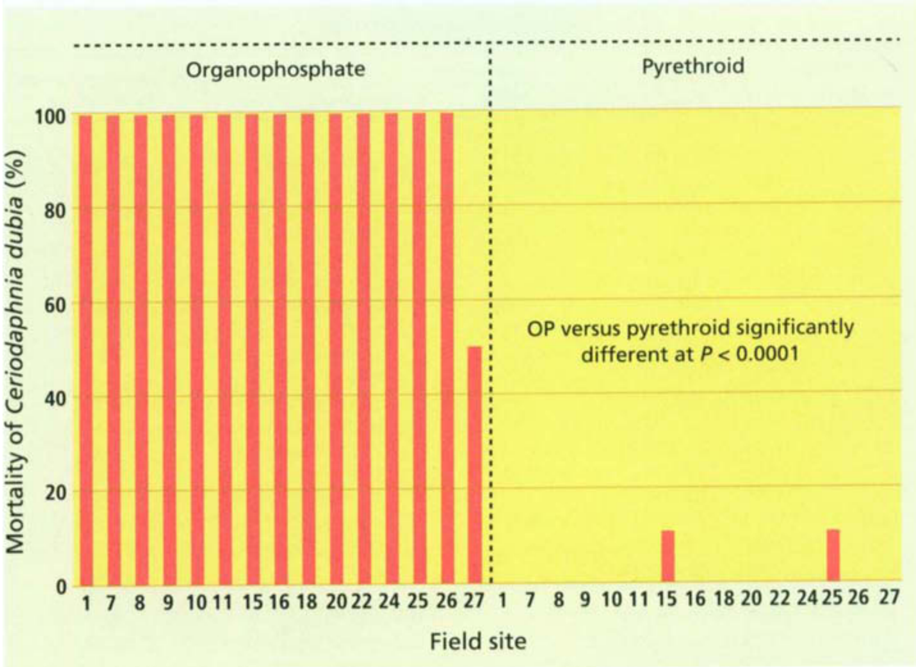

Fig. 1. Effect of insecticide choice on mortality of *C. dubia* (water flea) in a 24-hour test from 15 paired field comparisons, Sacramento Valley. Samples were taken from alfalfa tail water flowing from fields due to irrigation events after insecticide application. In all organophosphate tail-water samples, when piperonyl butoxide (PBO) was added mortality was zero; prevention of mortality with PBO is an indication of organophosphate toxicity. All organophosphate insecticide tail-water samples were diluted more than 85% before mortality of *C. dubia* was reduced to zero.

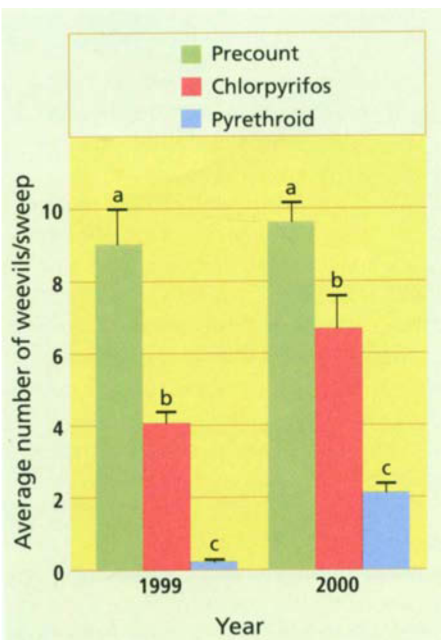

Fig. 2. Average number of weevils per sweep (± SE) in 1999 and 2000 for precounts (prior to treating fields) and for chlorpyrifos- and pyrethroid-treated fields (mean of 10 paired sites in 1999 and 8 paired sites in 2000). Different letters refer to significant differences between treatments at $P < 0.05$.

vil control, and one site was sampled during the second irrigation 62 days after treatment. All water samples were extracted into hexane within 24 hours after collection and stored at −4°F). All samples were analyzed using a gas chromatograph/mass spectrophotometer, to a detection limit of 50 ppt (parts per trillion [ppt]) for lambda-cyhalothrin.

Suspended solids. During each study year, we also collected total suspended solid (TSS) samples from irrigation source water and tail water from 15 of the study field sites to determine the quantity of soil particulate matter moving off alfalfa fields.

Insect counts. Insect populations were quantified in 1999 and 2000 in plots that were treated with chlorpyrifos or pyrethroids, by taking 10 sweeps with a standardized sweep net per treatment in four areas of the field. Average counts of beneficial insects and pests were recorded before and after fields were sprayed in March, and also just prior to the second, third and fifth harvests. Beneficial insects monitored included lady beetles (*Hippodamia* spp.), lacewings (*Chrysoperla* spp.), minute pirate bugs (*Orius* spp.), big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), aphidiid wasps and *Collops* beetles. Pests included Egyptian alfalfa weevil, pea and blue alfalfa aphid (*Acyrthosiphon* spp.) and spotted alfalfa aphid (*Therioaphis* sp). In 2000, aphids were sampled by taking 10 stem samples per plot in four areas of the field and recording averages per stem per treatment. Insect counts were pooled for the pyrethroid (lambda-cyhalothrin and cyfluthrin) treatments because there were no significant differences in insect counts between these treatments ($P > 0.05$). Data were analyzed using a one-way ANOVA with Tukey-Kramer HSD for means separation.

Water sampling for insecticides

We made direct comparisons between organophosphate- and pyrethroid-treated areas in 16 fields. Several other experimental sites were eliminated due to contamination of the pyrethroid treatment with an organophosphate insecticide, no water runoff, source-water contamination, no paired treatments, application change, no weevil treatment, no pyrethroid sample or no confirmation of organophosphate mortality (table 2).

Organophosphates. In 1999 and 2000, 14 of 16 tail-water samples collected from organophosphate-treated alfalfa plots caused 100% mortality to *C. dubia* within 24 hours (fig. 1). One chlorpyrifos-treated tail-water sample caused 100% mortality in 3 days (site 3), and one phosmet tail-water sample caused 50% mortality within 1 day (site 27). The source-water samples from these same fields had nearly zero mortality, except three sites (16, 25, 27) that had between 10% and 20% mortality. This low level of *C. dubia* mortality in the source samples could have been due to the presence of toxins in the source water, or natural variation in the response of the organism in laboratory tests. Mortality in laboratory control water was zero in all but one of the sites in a 24-hour test.

Dilution tests. In a 96-hour dilution test, organophosphate tail-water samples collected from 18 sites were diluted to less than 15% of the initial concentration before mortality of *C. dubia* was reduced to zero. In most samples, it was necessary to dilute the samples to less than 6% of the initial concentration before mortality was zero. When PBO was added, the test organism survived in all these organophosphate-treated tail-water samples. After 96 hours, mortality in the laboratory control samples was between 10% and 20% at three sites (11, 18, 25). With PBO, mortality in the laboratory control samples was between 5% and 20% at six sites (9, 10, 12, 20, 22, 24). Mortality for these control samples was likely within the range of normal experimental variation. Dilution tests were not done for sites with less than 100% mortality after 24 hours (sites 3 and 27).

Pyrethroids. There was near zero mortality of the *C. dubia* in a 24-hour test in the samples collected from pyrethroid-treated alfalfa fields (fig. 1). Although slight mortality was observed in these treatments, these results are likely well within those that could be expected from natural variation in the control-water samples.

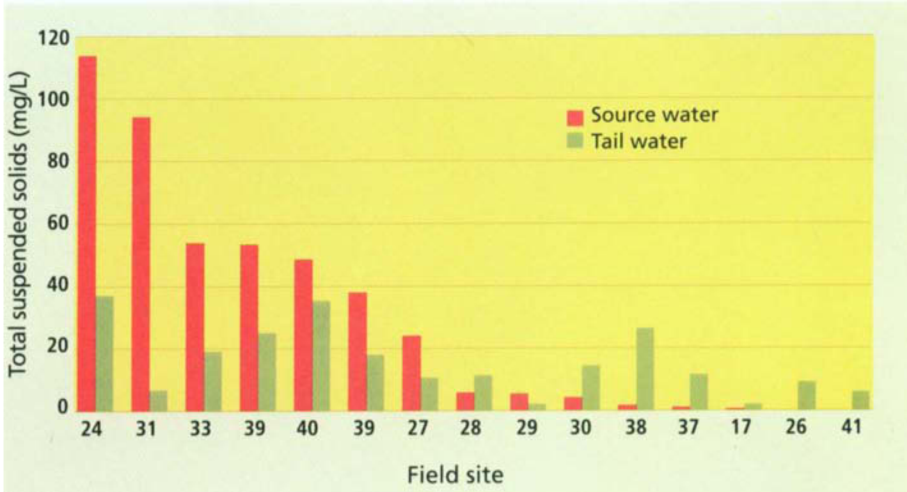

Fig. 3. Total suspended solids (TSS, mg/L) for source- versus tail-water samples, 1999–2001. Average TSS for source water was 30.1 mg/L versus 16.2 mg/L for tail water, with no significant difference at $P > 0.17$.

Pyrethroid analyses. Samples were taken in 2001 from six pyrethroid-treated fields, to analytically evaluate the presence of pyrethroids in tail-water samples. Lambda-cyhalothrin was not detected by gas chromatograph/mass spectrophotometer analysis in any of the source- or tail-water samples to a detection limit of 50 ppt (ng/L). Lambda-cyhalothrin added to source water (spiked) at 0.1 to 10 ppb resulted in recoveries ranging from 53% to 74%, substantiating that sampling methods did not interfere with detection (table 3).

Weevil control

In 1999 and 2000 the pyrethroid insecticides lambda-cyhalothrin and cyfluthrin controlled the Egyptian alfalfa weevil significantly better than the organophosphate chlorpyrifos, but both treatments kept the weevils below the threshold level of 15 to 20 larvae per sweep (fig. 2). In 1999 and 2000, there were no significant differences in beneficial insect counts between the chlorpyrifos or pyrethroid treatments (data not shown). There were no significant differences in aphid counts during harvests 1, 3 and 5 in the chlorpyrifos versus pyrethroid treatments. In the second harvest in 1999, there were significantly more aphids in the pyrethroid treatments compared with chlorpyrifos-treated fields, and similar trends (but lack of significance) in 2000.

Properties of insecticides

Regardless of the application rate or specific organophosphate insecticide applied for Egyptian alfalfa weevil control, exposure to irrigation tail water from all organophosphate-treated field sites caused mortality to *C. dubia*. In contrast, we did not observe significant *C. dubia* mortality in irrigation tail water collected from pyrethroid-treated alfalfa fields, nor did we find pyrethroid residues in tail-water samples to a detection limit of 50 ppt (ng/L).

TABLE 3. Detection of lambda-cyhalothrin insecticide by gas chromatograph/mass spectrophotometry (GC/MS) in source- and tail-water samples from six fields where this insecticide was applied, 2001

Water sample*	Field site	Lambda-cyhalothrin detection (mean) and percent recovery
Source	32–37	ND†
Tail	32–37	ND
Control: 0.1 ppb added	32	0.0534 ppb (53.4%)
Control: 0.1 ppb added	34	0.0681ppb (68.1%)
Control: 10 ppb added	33	7.4 ppb (74.0%)

* Lambda-cyhalothrin was added to source water from three fields (spiked) for control samples. Water samples were extracted into hexane within 24 hours of collection.

† ND = not detected; concentration of lambda-cyhalothrin was less than 50 ppt (0.05 ppb).

Pollution from sediment in runoff, *above*, was not found to be a significant problem on the alfalfa farms tested.

Differences in solubility, binding coefficients and toxicity (table 1) may account for the differences we found between classes of compounds. Pyrethroids are hydrophobic with very low water solubility. They are rapidly adsorbed to leaf surfaces and soil organic matter and apparently are not readily transported in runoff in the aqueous phase (table 1). Pyrethroids can move off-site attached to soil particles, where they may accumulate in silt deposits and potentially provide a source of exposure to aquatic life.

For alfalfa, this does not appear to be a severe problem because its deep roots and vigorous canopy help protect the soil from being transported during irrigation or due to wind erosion. The total suspended solids (TSS) data collected during our study showed that very little soil or sediment moved off-site in irrigation tail water (fig. 3). The concentration of TSS in irrigation source-water samples averaged 30.1 ± 9.5 mg/L compared with 16.2 ± 2.9 mg/L for tail water, a difference that was not statistically significant ($P > 0.17$). However, where source water was high in TSS, there was a tendency for a reduction in TSS in the tail water (fig. 3), indicating that the alfalfa crop may trap sediments. Particulate matter moving from agricultural fields may be subject to TMDLs in the future. The National Academy of Sciences considers 25 mg/L a very high level of protection for aquatic life, which in most cases was met in our tail-water samples.

In contrast to pyrethroids, organophosphate insecticides are moderately water-soluble, have lower binding coefficients than the pyrethroids, and may move in solution with irrigation or rainwater (table 1). Exposure to tail-water samples, 22 to 62 days after organophosphate field application and diluted to 15% to 1.6% of the initial concentration, still resulted in *C. dubia* mortality in a standard 96-hour toxicity test. Similarly, in a previous study researchers showed *C. dubia* mortality in irrigation tail water collected from chlorpyrifos-treated alfalfa fields up to seven irrigations after application (deVlaming, unpublished data).

Tradeoffs: efficacy, pest control

The efficacy of weevil control in pyrethroid-treated fields was significantly better than in the organophosphate-treated fields in our studies (fig. 2). However, weevil levels were below economic thresholds in most cases. Entomologists have been cautious about the use of pyrethroids in alfalfa due to potential impacts upon beneficial insects and insect interactions, possibly causing outbreaks of other pests that could require additional insecticide treatments (L. Godfrey, C. Summers, personal communication). Alfalfa is also considered a year-round reservoir for beneficial insects that may help control pests in other crops (such as cotton) and excessive pyrethroid use may disrupt this important function.

In our study we did not observe any adverse effects of pyrethroid use in alfalfa on beneficial insect populations, as compared with chlorpyrifos treatments. This could have been due, at least in part, to timing. Entomol-ogists have known that proper timing of insecticide applications may produce a selective action on the pest and natural enemy complex. The alfalfa fields in our study were treated in late winter/early spring when aphid and beneficial insect popu-lations were extremely low. Other studies have shown similar results in alfalfa, where early-season treatment for Egyptian alfalfa weevil had minimal effects on beneficial insects.

We did observe an effect on aphid populations during the second harvest period. In 1999 there were significantly more aphids in the pyrethroid-treated plots during the second harvest, and the same trend was observed during 2000. However, these aphid counts declined significantly by the third cutting and never required insecticide treatments.

There are often limitations and tradeoffs with regard to pesticide choice in terms of efficacy, effect on nontarget organisms, economics, and risks to the environment. The use of pyrethroids and their potential impact upon beneficial insects must be weighed against the propensity of organophosphate insecticides to move off-site in tail water.

Clean water laws are targeted to protect beneficial water uses such as habitat for wildlife and aquatic organisms. Insecticide choice may be an important factor to consider in areas where alfalfa runoff affects waterways. *Above*, birds feed on insects and rodents in fields near an irrigation water source.

Insecticide choice, water quality

This study demonstrated that alfalfa fields sprayed with organophosphate insecticides have the potential to contribute concentrations of organophosphates in tail water sufficient to cause mortality in the test organism *C. dubia*. Mortality occurred in all the observed field sites 22 to 62 days after application under a range of application rates and field conditions. Samples required considerable dilution before mortality was eliminated, suggesting that prevention of organophosphate runoff by growers may be difficult without changes in pest control techniques or irrigation practices. The group of pyrethroid insecticides we examined was not detected in tail water. They were effective at controlling the targeted Egyptian alfalfa weevil in our study and had no effects on beneficial insects.

However, the potential of pyrethroids to affect beneficial insects, and their high toxicity to fish (especially from application drift onto waterways), should be carefully considered when choosing insecticides. Many factors may influence the movement of insecticides, such as agronomic practices in different crops, soil type and pesticide properties including water solubility (Werner et al. 2002). While the full biological significance of *C. dubia* mortality caused by organophosphate insecticides is not known, choice of insecticide may be important to prevent contamination in areas where surface water runoff from alfalfa fields directly impacts natural waterways.

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Pheromones control oriental fruit moth and peach twig borer in cling peaches

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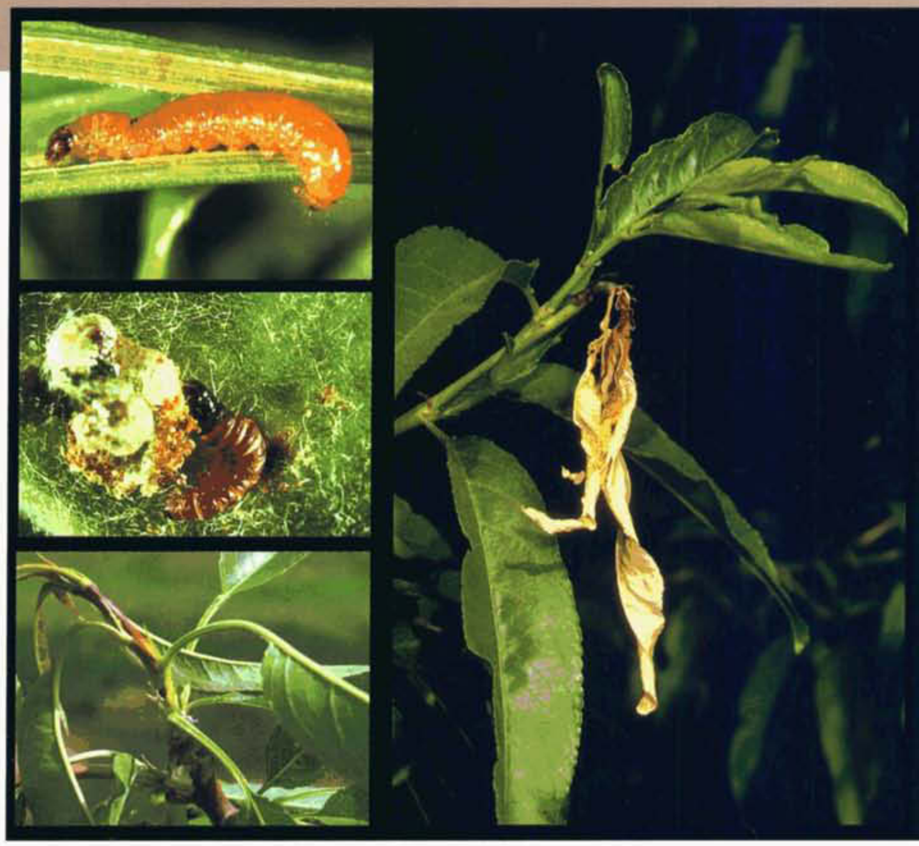
Walt Bentley
William H. Olson ■ Joe Grant

Slow-release pheromone technology can successfully control oriental fruit moth and peach twig borer while eliminating in-season insecticide sprays in cling peaches. In conjunction with a demonstration program, we compared mating disruption for these two pests with standard grower pest-control methods in the Sacramento and San Joaquin valleys, and monitored for pest damage, yield and grower costs. While the mating-disruption program was effective in controlling the targeted pests, costs were higher and growers preferred a partial disruption program that included some supplemental late-season insecticide sprays. Subsequently, we developed monitoring methods to determine the need for supplemental sprays. This partial mating-disruption program still costs about $60 more per acre than a standard spray program. Predicting efficacy and determining the need for supplement sprays is also more difficult with the partial program than with the pheromone-based control program.



The major pests of cling peaches are oriental fruit moth, *upper left*, and peach twig borer, *left middle*. These pests can bore into the terminal of the leaf, *lower left*, and cause it to wither and die, *right*. Broad-spectrum insecticides are effective in controlling these species, but can cause other problems such as insect resistance and secondary pest outbreaks. *Photos by Jack Kelly Clark*.

Most insecticides applied to cling peaches target two key insect pests: oriental fruit moth and peach twig borer. Both are lepidopteran pests that infest the fruit as it matures. Broad-spectrum toxic pesticides such as azinphos methyl, permethrin and esfenvalerate are effective in controlling these species. However, they have other problems such as contamination of surface water due to runoff from orchards, field-worker and pesticide applicator safety concerns, and the development of pest resistance due to overuse (Barnett 1994). Most in-season insecticides currently used by cling peach growers are disruptive to beneficial arthropods, increasing secondary pest resurgence and often requiring preventative mite sprays.

In 1987, products for managing oriental fruit moth (*Grapholitha molesta*) utilizing slow-release pheromone technology became commercially available as an alternative to broad-spectrum sprays (Weakley et al. 1987). When orchards are treated with pheromones, the air in the tree canopy is saturated with the synthetic species-specific pheromone used by females to attract males for mating. This technology confuses males, making it difficult for them to locate native females and resulting in less mating. Pheromone traps placed in pheromone-treated orchards in 1988 eliminated male flight. Between 1987 and 1995, approximately 6,000 acres were annually treated with pheromones to control oriental fruit moth, representing 22% of California's 27,000 cling peach acres. Growers with oriental fruit moth populations resistant to azinophos methyl (Guthion) readily adopted this mating-disruption technology. Other growers were reluctant because they still had to spray for peach twig borer (*Anarsia lineatella*). In 1995, the first commercial peach twig borer product using pheromones became available, allowing further adoption of this technology and decreasing the use of insecticides.

We introduced a pheromone-based

TABLE 1. Blocks and commercial products participating in the mating-disruption demonstration by county, 1995–1997

County	Year	Blocks	Acres	Paired comparisons	OFM* I†	OFM* C	OFM* H	PTB C	PTB H	Blocks with Bt pheromone	Partial program blocks
Butte	1995	7	42	1	5	2	0	6	1		
	1996	13	116	0	2	11	0	6	7		
Sutter /Yuba	1995	14	105	5	0	8	6	8	6		
	1996	12	179	10	9	2	1	2	10		
	1997	19	105	6	4	15	0	16	2	16	6
San Joaquin	1996	4	15	4	0	4	0	4	0	0	0
Merced	1996	6	48	0	0	5	1	2	1	1	2
	1997	4	27	1	0	0	0	4	0	0	0
Kings	1996	7	16	1	0	1	6	4	1	0	2
	1997	2	19	2	0	2	0	2	0	0	0

* OFM = oriental fruit moth; PTB = peach twig borer; Bt = *Bacillus thuringiensis.*

† I = Isomate; C = Consep; H = Hercon.

integrated pest management (IPM) program to cling peach growers in 1995 through on-farm demonstrations. The program — supported primarily by USDA-ES IPM Smith Lever Funds, the Cling Peach Advisory Board and the California Department of Pesticide Regulation — was designed to determine if pheromone mating disruption of oriental fruit moth and peach twig borer, using commercially available dispensers, provided acceptable control across a range of growing conditions. Another purpose was to develop a monitoring program for identifying secondary pests.

In 1995 and 1996, growers used a complete pheromone-based program for both pests; supplemental sprays were applied only when indicated by monitoring. In 1997, a partial program was developed by growers to incorporate pheromones by making one application of oriental fruit moth and peach twig borer dispensers rather than the two applications necessary for season-long control. The partial program was supplemented with planned sprays for later generations of oriental fruit moth before harvest. Many growers preferred this partial program because it minimized costs while still providing good control.

In 1995, 16 cooperators participated with 21 blocks that included 151 acres treated in the Sacramento Valley (Butte, Sutter and Yuba counties). The growers purchased pheromone dispensers for oriental fruit moth, and the project provided field pest monitoring and pheromone dispensers for peach twig borer. Supplemental financial and monitoring support was provided to familiarize growers with pheromone confusion as a pest control program.

In 1996, we expanded the program to the San Joaquin Valley, and federal programs allowed individual growers to recover up to $3,500 in pheromone-application costs. There were 18 cooperators in 1996 with 25 blocks for a total of 295 acres treated in the Sacramento Valley. The San Joaquin Valley had 10 cooperators with 17 blocks for a total of 79 treated acres in Kings, Merced and San Joaquin counties.

In 1997, the project had 151 acres following the pheromone-based IPM program and 229 acres following the partial program, in six counties with 22 cooperators. Over the 3-year period, the pheromone-based program for oriental fruit moth and peach twig borer was used on 672 acres (table 1).

In 1997, 246 acres were also treated with *Bacillus thuringiensis* (Bt) during bloom, eliminating the use of a dormant insecticide spray. Previous demonstrations utilizing Bt bloom sprays on peaches and prunes showed control of overwintered peach twig borer as well as reductions in bloom damage by obliquebanded leafroller, fruittree leafroller, green fruitworm and cankerworm (Barnett 1992, 1993).

Mating-disruption program

Three commercial suppliers (Pacific Biocontrol, Consep and Hercon) produced the pheromone dispensers used in the demonstration project, each with different designs and amounts of pheromone active ingredients. Pacific Biocontrol's Isomate for oriental fruit moth had a recommended application rate of 30 grams active ingredient per acre (ai/acre); Consep's Checkmate applied 19.44 grams ai/acre for oriental fruit moth and 20 or 24 grams ai/acre for peach twig borer; and Hercon's Disrupt applied 27 grams ai/acre for oriental fruit moth and 20 grams ai/acre for peach twig borer. The recommended time between applications varied for each product and we followed manufacturers' guidelines. The three oriental fruit moth products were recommended for reapplication at 90 days, with the peach twig borer products recommended at 60 to 90 days.

When the first pheromone-confusion product was registered in 1987, the manufacturer recommended application at the historic date of the first moth. This can be 2 to 3 weeks earlier than when the actual first moth is trapped, depending on conditions that year. Delaying the first pheromone application until the first moth is caught extends the activity to later in the season, when insect populations are more damaging. The biofix, which is the first actual moth trapped for the season in a particular orchard, is usually much later in orchards that have previously used pheromones for control. In this study the first application of oriental fruit moth pheromone was typically March 1, and for peach twig borer April 1. Since the fruit moth products and Hercon's peach twig borer product lasted 90 days and the Consep peach twig borer product lasted 60 days (1995), the second application of dispensers for both pests was around June 1 in the Sacramento Valley orchards. Although this reapplication was earlier than the recommended 60 days for peach twig borer dispensers, growers were able to save the cost of an additional application by placing both dispensers at the same time. Growers in Kings and Merced counties applied oriental fruit moth and peach twig borer dispensers separately resulting in four discrete applications (twice for each type). We advised growers to monitor pheromone traps for the first moth caught of

In a demonstration project, cling peach growers in the Sacramento and San Joaquin valleys were introduced to pheromone disruption as a method to control oriental fruit moth and peach twig borer. Several different commercially available products were tested, *left* and *center*. *Right*, A pheromone trap is used to monitor pest levels in the orchard.

each species to determine the application timing.

Growers were also encouraged to place the dispensers in the upper one-third of the tree canopy, since pheromones are heavier than air and sink to the ground. The entrance of larvae causes the terminal shoot growth of plants to wilt and die, which is called a shoot strike. When growers apply pheromone dispensers too low in the tree canopy, a high number of shoot strikes will occur, indicating the need for supplemental sprays.

Field monitoring

The demonstration blocks ranged from 5 to 38 acres. Because past mating-disruption programs worked better in uniform blocks greater than 10 acres, growers with small orchards were closely monitored to limit fruit damage. However, pheromone confusion can be more successful in small blocks if they are isolated from potential moth sources. The easiest method to evaluate control is with pheromone monitoring traps. If no moths are caught the mating disruption should be working, because males cannot find the traps. We followed weekly pheromone trap catches throughout the season for both pests. In most blocks, a nearby conventional or "standard grower" was monitored for trap-catch comparisons and to pinpoint moth flight for each generation of both species. Traps in disrupted orchards should catch no oriental fruit moth and only a few peach twig borer.

In 1995, some of our mating-disruption blocks sustained shoot-strike damage even when no oriental fruit moths were caught in pheromone traps, indicating the need for supplemental sprays. With peach twig borer, however, we could catch low numbers of moths and have no corresponding damage at harvest. For this reason we recommended monitoring shoot strikes to evaluate control during the season. In the Sacramento Valley, shoot-strike counts were taken in each orchard at the end of each oriental fruit moth generation.

It is often difficult to determine which species caused the shoot strikes because the larvae may not be present. To determine the primary species causing strikes, samples should be taken at 500 degree-days from the oriental fruit moth biofix for each generation, when larvae are expected to start causing shoot strikes. In the San Joaquin Valley, shoot strikes were monitored in late May or early June in all locations by counting total strikes per tree from a minimum of five trees in each variety or block. Live larvae were examined and identified from the strikes when possible. Sprays were recommended when an average of three to five strikes per tree was found.

For the harvest sample, 500 peaches in the Sacramento Valley and 1,000 peaches in the San Joaquin Valley were examined from each variety in a block. The fruit were collected in groups of 100 in five or 10 different locations per block. They were evaluated for oriental fruit moth and peach twig borer damage, and live larvae were identified by species. They were also evaluated for secondary pest damage by leafroller, stinkbug and katydid.

We also used traps to monitor for San Jose scale in all locations. Omnivorous leafroller pheromone traps were used in the San Joaquin Valley. Peach blocks next to walnut orchards in the Sacramento Valley were monitored with codling moth pheromone traps, and peaches next to riparian vegetation were monitored for stinkbug. Damage to fruit from secondary pests was scored at harvest.

Trap-catch results

The three pheromone products caught significantly less than the standard grower method, but were not different from each other (table 2). In the Sacramento Valley, 87% of the blocks caught two or fewer moths per season, compared with 38% in the San Joaquin Valley. All the blocks that caught three or more moths in 1995 required a supplemental spray, but one block in 1996 was not sprayed because shoot strikes never reached damaging levels. The decision to spray additional blocks was based on finding more than three to five shoot strikes per

TABLE 2. Seasonal total oriental fruit moth (OFM) and peach twig borer (PTB) trap catch, 1995–1997*

	OFM†				PTB‡			
Treatment	No.	Range	Mean	SD§	No.	Range	Mean	SD
Standard grower	20	0–455	74.8	109.5	31	2–663	133.0	173.1
Consep	31	0–5	1.45	1.53	19	0–19	16.32	51.6
Hercon	4	0–1	0.25	0.5	13	0–2	3.15	4.1
Isomate	8	0–6	1.0	2.1				

* One-way analysis of variance from all paired comparison blocks.
† Standard grower treatment was significantly different from the three pheromone treatments ($F = 4.66$, $P > 0.0055$).
‡ Standard grower treatment was significantly different from the two pheromone treatments ($F = 7.47$, $P > 0.0013$).
§ Standard deviation.

tree, rather than solely on trap catches. The standard-grower comparison blocks with high seasonal totals of oriental fruit moth — ranging from 0 to 455 — are the only available measures of potential populations levels in the area (table 2).

Previous research has shown that pheromone confusion does not work as well in orchards with high pest populations. In general, the San Joaquin Valley does not have as high oriental fruit moth populations as the Sacramento Valley, as demonstrated by the lower seasonal totals found in the standard grower treatments. The highest catch in a standard grower's orchard in 1 year was 243 moths in the San Joaquin Valley and 455 moths in the Sacramento Valley. However, in the San Joaquin Valley in 1996 and 1997, 61% of the mating-disruption blocks caught a seasonal total of more than three moths, indicating that mating disruption may not have been adequate and supplemental sprays may be warranted if shoot strikes so indicate.

The use of trap catches to evaluate the effectiveness of mating disruption for peach twig borer is less clear. For oriental fruit moth, field practitioners have felt confident relying on trap-catch shutdown, when the traps fail to catch moths because they cannot find the source of the pheromone. Although field practitioners should not rely solely on trap catches, they are the first indication of potential problems. In our study, we found that trap shutdown is not always linked to adequate control of peach twig borer. The total seasonal trap catch and damage at harvest shows a good correlation ($R^2 = 0.81$) with the mating-disruption orchards combined and a poor correlation ($R^2 = 0.11$) with the standard grower orchards (fig. 1). Most of the blocks caught six or fewer peach twig borer during the season. None of the growers had to spray or incurred peach twig borer damage.

Nonetheless, in Merced County one block caught 228 peach twig borer moths in mating-disrupted orchards and subsequently had substantial damage, indicating that mating disruption was no longer occurring. The populations of peach twig borer are

Pheromone dispensers can be placed in the tree using ladders or from a truck, *above.* Costs for various application methods were measured.

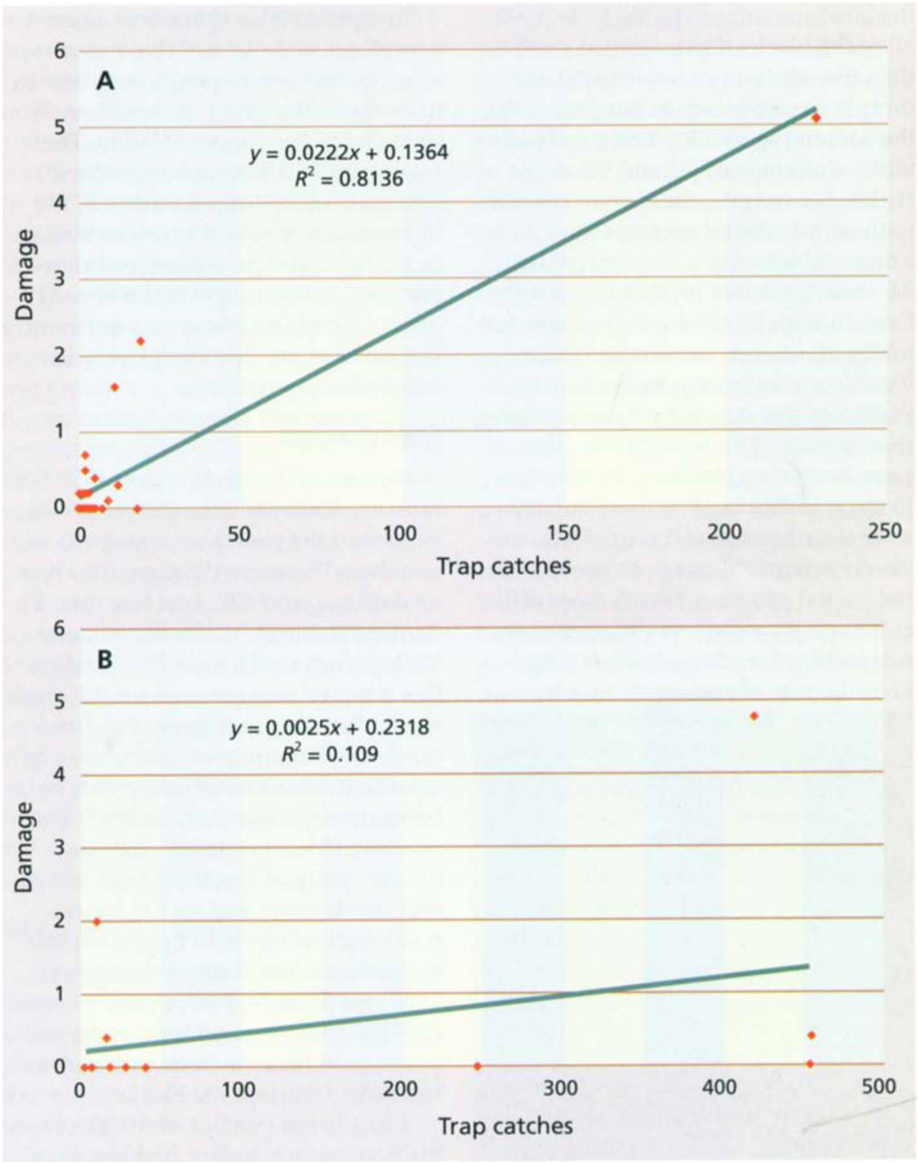


Fig. 1. Correlations from (A) mating-disruption treatments and (B) standard-grower treatments between peach twig borer seasonal total trap catches and damage at harvest.

much higher in the San Joaquin Valley, especially in Merced County where almond orchards that do not spray for peach twig borer surround many peach orchards. It is more difficult to use pheromone confusion successfully under these conditions. In cases such as Merced County, where untreated almond orchards are located near peaches, the migration of mated moths from the almonds to the peaches occurs and defeats the mating-disruption process.

Project manager Cressida Silvers, *photo at left*, worked with numerous cooperators, including, *right*, grower Lance Jackson (left) and pest control advisor John Ricomini. Because of higher costs, many of the participating growers preferred a partial program that incorporated pheromone disruption and limited spraying.

Shoot-strike results

In all three years the strike counts for both species were very low until the late June sample (table 3). In 1995, all of the blocks that averaged more than five strikes per tree in the June sample were treated. In late June 1996, the Sacramento Valley had two blocks with an average of 5.3 and 5.1 shoot strikes per sample; these were treated with supplemental sprays. One Sutter County block with a late variety had 3.8 strikes per tree in the June sample. Even though this block had caught no moths all season, first instar larvae were found in fruit in early August; the block was sprayed to prevent further damage. The June shoot-strike sample was not conducted in the San Joaquin Valley in 1996 since the trees were near harvest and two blocks suffered economic damage at harvest. In the partial program, it was more difficult to predict when populations of oriental fruit moth and peach twig borer increased enough to require spraying, because traps were not tracking moths well enough to determine optimum timing.

In April 1997, a shoot-strike count was taken at the end of the overwintered generation of peach twig borer to evaluate the effect of two Bt applications in the Sacramento Valley. There was a mean of 0.04 and a standard deviation of 0.09 shoot strikes in the Bt-treated blocks and no shoot strikes in the standard-grower paired comparisons, indicating that the Bt program was as successful as a dormant insecticide for controlling overwintered peach twig borer.

TABLE 3. Shoot-strike sample taken at two sample periods for treatments in mating-disruption demonstration project, 1995–1997*

	May sample†		June sample‡	
Treatment	Mean	SD§	Mean	SD
Standard grower	1.8	1.1	1.1	1.7
Consep	0.3	0.5	2.2	3.7
Hercon	0.1	0.1	1.5	1.6
Isomate	0.2	0.2	0.9	1.4

* One-way analysis of variance from all paired comparison blocks.

† Statistically significant difference ($F = 7.05$, $P < 0.0028$) between standard grower and the three pheromone treatments.

‡ No statistically significant difference ($F = 0.29$, $P > 0.83$) between the standard grower and the three pheromone treatments.

§ Standard deviation.

Fruit damage

Infestation levels in most of the Sacramento Valley blocks (97%) over all years met the processor standards of less than 3% larvae damage; 34% had no damage, and 63% had less than 3% damage (table 4). In the Sacramento Valley blocks with over 3% damage, this damage was not seen on the grade sheet after fruit sorting by the growers. In the Sacramento Valley the highest oriental fruit moth and peach twig borer damage was 2.4% in 1995. This was an extra-late variety in Butte County planted in a triangular block, and the damage was on the outside rows, indicating moth migration into the orchard. The highest damage in 1996 was 2.6%. In 1997, overall worm damage from oriental fruit moth and peach twig borer in both valleys was less than 1.6% in most blocks.

Sixty-seven percent of the blocks in the San Joaquin Valley had less than 3% damage at harvest, but four blocks in Merced County exceeded 3% damage. Oriental fruit moth caused the most damage in the Sacramento Valley, as opposed to peach twig borer in the San Joaquin Valley. Growers in San Joaquin and Kings counties had less damage than in Merced County, where three orchards had peach twig borer damage over acceptable levels (3.5%, 3.6% and 7.5%). The block with the highest damage also had 3% damage from oriental fruit moth. In Merced County, high peach twig borer pressure came from nearby untreated almond orchards. The average damage due to oriental fruit moth and peach twig borer for the partial pheromone blocks in 1997 was 0.04 with a standard deviation of 0.009; this was comparable to the standard-grower paired comparison with mean damage of 0.65.

Secondary pests

No damage problems were seen at harvest from either San Jose scale or mites in all years. One block in Sutter County had codling moth damage in three rows next to an unsprayed walnut orchard. The leafroller damage mean was 1.1% with a standard deviation of 1.5; this was from the summer leafroller generation. Three blocks had more than 3% damage (3.2%, 3.2%, 7.1%), which is the industry grading threshold for rejecting a load. The mean for stinkbug damage was 0.22%, and the standard deviation was 0.47.

Growers in the San Joaquin Valley had substantial damage from katydid (as high as 3.9% in a block in Merced County), but the rest had less than 0.3% katydid damage. This pest has developed into a severe problem in unsprayed pheromone-confusion orchards in the San Joaquin Valley.

TABLE 4. Total damage of total oriental fruit moth (OFM) and peach twig borer (PTB) at harvest for 3 years*

	OFM†			PTB‡		
Treatment	No.	Mean	SD	No.	Mean	SD
Standard grower	14	0.5	1.1	17	0.7	1.3
Consep	13	0.6	0.9	14	0.5	1.3
Hercon	3	0.2	0.2	13	0.2	0.4
Isomate	6	0.0	0.0	—§	—	—

* One-way analysis of variance from all paired comparison blocks.

† No statistically significant difference for mean OFM damage between treatments ($F = 0.66$ and $P > 558$).

‡ No statistically significant difference for mean PTB damage between treatments ($F = 0.59$ and $P > 0.56$).

§ No data. Isomate does not make a PTB disruptant product.

TABLE 5. Mating-disruption costs compared with standard spray programs for Sacramento Valley growers to control oriental fruit moth (OFM) and peach twig borer (PTB)

Year	*1995*	*1996*	*1997*
Number of growers	11	20	9
	Average costs/acre ($)		
OFM pheromone*	96.60	92.12	90.20
PTB pheromone*	115.00	101.56	109.76
Application costs	50.31	37.90	18.57
Total costs	243.00	231.58	218.53
Partial (OFM + PTB + 1 spray)†	—	—	158.93
Partial (OFM + PTB + 2 sprays)†	—	—	182.18
Standard grower	110.07	109.00	93.48

* Two applications.

† One application.

Katydid populations increase in the spring and may feed on the fruit from May through August. They can be monitored using a beating tray or sweep net, or by simply looking for feeding damage on fruit.

Economic analysis

We also conducted an economic analysis of grower costs in the Sacramento Valley from 1995 to 1997 (table 5). At the end of each season, pheromone dispenser costs, application methods and application costs were collected from 11 cooperators in 1995, 20 in 1996 and nine in 1997. The average dispenser cost per acre for two oriental fruit moth applications decreased from $96.60 in 1995 to $90.60 in 1997. The average dispenser cost per acre for two peach twig borer applications declined from $115.00 to $101.56 over the 3-year period; the price of pheromone dispensers for all four applications dropped $24.47 from 1995 to 1997. According to suppliers, pheromone dispenser costs have remained stable since 1997.

We also tracked the amount of labor needed for various pheromone-application methods, and the costs incurred. One method is to move individual ladders through the orchard to place the dispensers in the tree; small ladders are easier to carry and move, requiring less time. In all 3 years, ladders were the most expensive application method, although using small ladders cost much less. Growers were able to lower the cost further by using specially designed poles to apply the dispensers from the ground. Application from a tractor-pulled trailer was the best method — and the least expensive — for getting dispensers high in trees; workers ride in a trailer and place the dispensers from a platform. For most application methods, excluding ladders, the average cost was $37.90 per acre for the season. Application cost plus the cost of pheromone was $243 per acre in 1995 and $231.58 per acre in 1996. This further decreased to $218.53 per acre in 1997 because growers began utilizing methods that allowed them to lower labor costs.

The costs of the pheromone program were also compared with the standard spray programs of participating growers in all three years. Over the 3-year period costs for the standard grower program ranged from $93.45 to $110.07 per acre. By 1997, the standard grower program was still $125.05 less than the complete pheromone program, enough of a difference to prevent growers from adopting it. The costs for the partial program were $59.60 lower per acre than the season-long pheromone program, and the total number of sprays is reduced compared with the standard grower. (Nonetheless, there is current evidence that spray programs are beginning to fail due to the development of pest resistance [unpublished data].)

Using mating disruption

Growers and pest control advisors should be aware of the grams of active-ingredient load rates for each pheromone dispenser product and use the one best suited to pest population levels in the block. They should check labels each year, follow the manufacturers' recommendation and know the pheromone application rate of each product. Based on our results, we recommend that growers use products with higher grams per acre when they first start a mating-disruption program. After several years, oriental fruit moth populations will be reduced, and some growers decrease the number of dispensers per acre. However, research has not yet determined how many years it takes to lower pest populations enough to reduce pheromone application rates. Field experience shows varied results depending on how high the population is and the potential for pest migration from surrounding orchards. Growers should be prepared at historic date of the first moth so that they can quickly make applications once the first moth is caught in standard pheromone-baited sticky traps.

Supplemental spraying can be a necessary part of using pheromone technology if resident moth populations are too high. However, over a period of years overall pest populations should drop and additional sprays may not be required. Growers starting a mating-disruption program will have different population levels of oriental fruit moth and peach twig borer in their orchards and different population sources from neighboring orchards. Monitoring is important to determine when supplemental sprays are necessary. If oriental fruit moth or peach twig borer is trapped, growers should monitor shoot strikes to determine the need for supplemental sprays. Blocks typically reached the treatment threshold at the June shoot-strike sample on late-season varieties. Cling peach varieties harvested in August are exposed to additional generations of both oriental fruit moth and

PHEROMONES — continued from previous page

peach twig borer, making mating disruption more difficult in these orchards.

Growers using mating disruption should be aware of potential pest populations bordering areas where they use pheromone-confusion technology. Damage in most blocks was linked to orchards with high oriental fruit moth and peach twig borer populations nearby. Growers in these situations may have to spray the edges of the orchard. This is especially true in peach orchards that lie near almond orchards, such as in Merced County.

Other costs associated with spraying, such as worker safety measures, should be considered in cost comparisons. For some growers, the benefits of a less hazardous workplace, pesticide reduction, no drift and less machinery maintenance, plus being able to irrigate and thin as needed, are worth the extra cost of the season-long mating-disruption program. This project showed that mating disruption is an effective alternative to conventional pest control methods. If the overall cost of pheromone dispensers decreases and growers lose currently registered less-expensive pesticides, we expect more peach growers to adopt pheromone confusion.

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NEXT ISSUE

Rice irrigation and salinity

Rice is one of the most sensitive crops to salinity. In the next issue of *California Agriculture*, research by UC scientists reveals that rice is even more salt-sensitive than current water management guidelines suggest, with yields suffering as a result.

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