California Agriculture

Examining <mark>obesity:</mark> What *should* we eat?

Also:

Networks for sustainability

Late-season navel oranges



Patricia B. Crawford Co-Director, Center for Weight and Health, UC Berkeley

Key partners working together to stem obesity epidemic

Childhood obesity is one of the most serious health problems facing our state. A child born today is three times more likely to be overweight by age 18 than a child born 30 years ago. Today's young children also face a onein-three lifetime risk of developing type 2 diabetes — if they are Latino, a 50% chance — and an increased risk of heart disease, hypertension and certain

forms of cancer. Our health care system, already stretched, may collapse under the "weight" of this situation.

Recognition is growing that the causes and solutions are not to be found in the health sector alone, but rather in the larger societal and environmental context. We must scrutinize the environmental factors that can act as barriers to healthy eating, including food cost, availability and marketing, as well as physical, economic and logistical limits on children's daily physical activity. For example, a study by the Kaiser Family Foundation found that a typical 8- to 12-year-old child may see more than 7,000 food and beverage commercials in a year, and few if any promote healthy foods such as fruits and vegetables. Fewer than 2% of our nation's children actually eat meals that meet the current recommended Dietary Guidelines.

California has responded by establishing food, nutrition and physical activity policies to protect the health of our children. Governor Arnold Schwarzenegger has made it a priority to address this issue and has championed many of these public policy efforts. Among the state's achievements is the passage of broad legislation governing the nutritional content of foods and beverages served in K-12 schools. This legislation was preceded by a pilot program to implement the new guidelines, conducted by the California Department of Education, funded by the California Department of Food and Agriculture, and evaluated by nutrition specialists with the UC Division of Agriculture and Natural Resources (ANR) and staff at the Center for Weight and Health at the UC Berkeley College of Natural Resources and School of Public Health. This study provided critical information on the feasibility of limiting foods and beverages of low nutritional value, increasing the consumption of Californiagrown fresh produce, and enhancing the quality of school lunch and student fitness programs.

Similarly, UC is collaborating with the California Department of Education on California Fresh Start, a program established by the state legislature in 2005 to provide a 10-cent-per-meal reimbursement to school districts that offer an additional serving of fruits or vegetables. The Center for Weight and Health is evaluating the program and identifying potential impacts for California agriculture and the state economy.

Nutrition faculty at UC Berkeley and UC Davis are also providing leadership. In this issue, scientists report on the interrelationship among asthma, magnesium and obesity (see page 119). In another study funded by the Centers for Disease Control, UC researchers analyze the literature on the dietary determinants of obesity (see page 112). While reports in the press have conflicting messages, this review synthesizes the research and identifies the factors most likely to protect against obesity: higher consumption of dietary fiber, fruits, vegetables and low-fat dairy products. UC nutrition, family and consumer science advisors (NFCS) are carrying this message to the public.

ANR has specifically created workgroups on nutrition, obesity and related health conditions. One recent workgroup project, summarized in this issue, examined the relationships among food insecurity, parental feeding practices and obesity in California's Latino population (see page 106). Another article describes the way in which nutrition advisors are forming countywide coalitions, effectively linking health, education and agriculture groups to more effectively tackle child obesity prevention (see page 124).

For example, ANR advisors are developing innovative programs to improve child nutrition by: collaborating with the Fresno County Farm Bureau to teach children about the link between healthy eating and agriculture; providing education about farmers' markets in Butte County; educating communities about fruits, vegetables and cooking methods in Sacramento County; working through the UC Small Farms Workgroup to help growers view their crops from a consumer perspective in Santa Clara County; establishing new farmers' markets in rural Tulare County; and supplying fresh produce for community events in Kern County.

Further, NFCS advisors are providing educational programs and materials in a variety of languages to individuals and agencies that serve low-income populations through the Expanded Food and Nutrition Education Program and the Food Stamp Nutrition Education program.

The obesity epidemic in children highlights the importance of working together in policy areas such as the Farm Bill reauthorization, now under way, to ensure that our food supply and nutrition programs support healthy eating. Limiting the focus to individual choice ignores the environmental context within which we make those choices. When the agriculture and nutrition sectors work together to address obesity, it can create a win-win situation that benefits both Californians' health and the agricultural economy of the state.

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Examining obesity: What *should* we eat?

As obesity rates climb, studies surge as well — sometimes resulting in contradictory claims about nutrition, weightloss and even ideal weight. In this special collection, our authors review a large body of scientific literature on obesity prevention, present new research findings and offer case studies of community interventions.

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About California Agriculture





California Agriculture is a quarterly, peer-reviewed journal reporting research, reviews and news from the Division of Agriculture and Natural Resources (ANR) of the University of California. The first issue was published in December 1946, making it one of the oldest, continuously published, land-grant university research journals in the country. The circulation is currently about 15,000 domestic and 1,800 international.

Mission and audience. *California Agriculture*'s mission is to publish scientifically sound research in a form that is accessible to a well-educated audience. In the last readership survey, 33% worked in agriculture, 31% were faculty members at universities or research scientists, and 19% worked in government agencies or were elected office holders.

Current indexing. *California Agriculture* is indexed in the Commonwealth Agricultural Bureau databases, Proquest, AGRICOLA and Google Scholar. In addition, all peer-reviewed articles are posted at the California Digital Library's eScholarship Repository.

Authors. Authors are primarily but not exclusively from ANR; in 2005 and 2006, 14% and 34% (respectively) were based at other UC campuses, or other universities and research institutions.

Reviewers. In 2005 and 2006, 13% and 21% (respectively) of reviewers came from universities and research institutions or agencies outside ANR.

Rejection rate. Our rejection rate is currently 26%. In addition, in two recent years the Associate Editors sent back 11% and 26% for complete resubmission prior to peer review.

Peer-review policies. All manuscripts submitted for publication in *California Agriculture* undergo double-blind, anonymous peer review. Each submission is forwarded to the appropriate Associate Editor for evaluation, who then nominates three qualified reviewers. If the first two reviews are affirmative, the article is accepted. If one is negative, we send the manuscript to a third reviewer. The reviewers and Associate Editors almost always require revision before acceptance. The Associate Editor makes the final decision, in consultation with the Managing and Executive Editors.

Editing. After peer review and acceptance, all manuscripts are extensively edited by the *California Agriculture* staff to ensure readability for an audience of lay readers and multidisciplinary academics.

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Letters

To our readers

Editorial work gets the gold

California Agriculture is pleased to announce that Executive Editor Janet White and Managing Editor Janet Byron won a Gold Award for Editing from the Association for Communication Excellence in Agriculture, Natural Resources, and Life and Human Sciences (ACE), for their work on "When crop transgenes wander in California, should we worry?" by Norman C. Ellstrand, Professor of Genetics, UC Riverside. The article was published in the July-September 2006 issue.

ANR Communication Services won two ACE awards for Weeds of California and Other Western States (Vols. 1 and 2), by Joseph DiTomaso and Evelyn Healy: the Gold Award for Technical Publications, and the Outstanding Professional Skill award for Publishing (among all ACE Publishing award winners). CS staff who produced the book were



July-September 2006 issue

Stephen Barnett, publications project manager; Jack Kelly Clark, principal photographer; Evett Kilmartin, media librarian; Steve Lock, senior photographer; Ray Lucas, senior producer/ director; Celeste Aida Marquiss, art director; Michael Poe, media services manager; Ann Senuta, publications production manager; and Bob Sams, CS unit director.

The CS staffers received their awards at the ACE annual conference in Albuquerque, N.M., on June 18.

California Agriculture changes address, telephone

As of June 15, *California Agriculture*'s offices have moved to:

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Our e-mail addresses and Web site URL will remain the same.

Yosemite article still educates

Thank you for locating May-June 1999 editions with the article "Past forest management promoted root disease in Yosemite Valley" (authored by myself and Dave Rizzo). I give talks in Yosemite Valley to various professional groups. The latest example was a small group of U.S. Forest Service pathologists and entomologists from Sonora who were interested in the historical-to-presentday root disease/bark beetle/tree hazard/ecology story in Yosemite Valley. I also plan to talk at the International Union of Forest Research Organizations on root and butt rots in Yosemite in August. People at these meeting often find the story interesting, and wish to read more. The California Agriculture article is ideal for handing out to these folks. I have given talks to the general public (including my own family), and have handed out copies. I have sent it to media workers, both TV and written, when the need arises.

Garey Slaughter UC Davis (retired)

Master Gardener enjoys Cal Ag

I enjoyed finding you in my mailbox — both electronic and metal. Good stuff — and easy to share with the rest (world, family, friends). I have been a reader of *California Agriculture* for 9 years. I believe the information is vital and the e-mail notification is a good tool to spread the word. I have lived in Sonoma County for the past 15 years, and have received California Agriculture since becoming a Master Gardener in 1990. After moving to Sonoma County I became interested in restoration and conservation, and was involved in elementary school "life labs" and gardens. I graduated from the Santa Rosa Junior College in 1994 majoring in horticulture. I am again a student at SRJC, focusing on garden design with CAD skills and integrating the important factors involved with our natural resources. I became a Creekkeeper in 2005 and was in the first graduating class implemented by the Russian Riverkeeper. I continue to read and share the information I learn from your journal.

Patty Mohar Sonoma County



May-June 1999 issue



The 700-page California Master Gardener Handbook, published by ANR Communication Services, can be ordered at http://anrcatalog. ucdavis.edu, or by calling (510) 642-2431 or (800) 994-8849.

Outreach news

<abir/SAFS</pre>





Left, researchers Patricia Lazicki (left) and Diana Staley sample tomatoes at the 19-year-old UC Davis Sustainable Agriculture Farming Systems (SAFS) project research site. Inset above, at the SAFS plot, conservation and standard tillage are compared in conventionally grown corn.

UC Davis institute focuses on sustainability

A recent search on Google for "sustainable agriculture" brought up more than 40 million results. And with global attention increasingly focused on related issues such as climate change (103 million results), food safety (147 million results) and food systems (224 million results), interest in sustainable agriculture — and sustainability in general — has never been greater.

One definition of sustainable agriculture is using methods that attempt to ensure the profitability of farms while preserving the environment and meeting the needs of society as a whole. UC research has reflected the world's interest in the concept, and now the numerous projects related to sustainability have a central home — the new Agricultural Sustainability Institute (ASI) at UC Davis.

"We hope to shape a forward-looking agenda for research, education, communication and engagement to support action on big, emerging issues in agriculture and the food system," says Tom Tomich, who joined ASI as director in January 2007.

ASI was originally conceived in 2005, and jump-started with a \$1.5 million gift from the W.K. Kellogg Foundation, which endowed a chair (held by Tomich) to support the institute. ASI is intended to provide a hub that links initiatives in sustainable agriculture and food systems across all departments of the UC Davis College of Agricultural and Environmental Sciences, across UC, and with other partners throughout the state.

National, global scope

Tomich says that in addition to being a hub for UC and state partners, ASI will provide a focus for related national and international initiatives.

"Scientists and politicians around the world are now in general agreement that humans are one of the biggest forces that shape Earth's ecosystems," says Tomich, who spent the last 6 years in Nairobi, Kenya, as global coordinator of ASB, the Partnership for the Tropical Forest Margins at the World Agroforestry Center. "Research data shows that humans have transformed almost half the land area on the globe, and over half of our marine fisheries are over-exploited. Less known but frightening for the agricultural community is the fact that humans are responsible for more than half of all nitrogen-fixation, in the form of synthetic fertilizer, on the Earth."

Tomich says his goal will be to integrate activities across an evolving agenda including sustainable agriculture and the food system, plant and animal science, environmental and natural resource stewardship (see page 131), and social and economic issues.

"We intend to identify scientific principles and practices that enhance sustainable agriculture and the food system, and to produce results to meet the needs of the people of California, and, in turn, the nation and world," he says.



Tom Tomich, director of the Agricultural Sustainability Institute at UC Davis and the statewide UC Sustainable Agriculture Research and Education Program, will focus on emerging issues in agriculture and food systems.

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Programs and projects

At UC Davis, Tomich also serves as director of the UC Division of Agriculture and Natural Resources (ANR) Sustainable Agriculture Research and Education Program (SAREP), the first program of its kind at a land-grant university in the nation. The W.K. Kellogg Foundation has provided a \$95,000 grant to help ASI initiate and host an annual symposium series on agricultural sustainability and food systems, beginning in fall 2008.

The current programs and main projects of ASI include the 20-year-old SAREP; the 30-year-old UC Davis Student Farm, including the Children's Garden; the 17-year-old UC Davis Long-term Research on Agricultural Systems (LTRAS) project; the 19-year-old Sustainable Agriculture Farming Systems (SAFS) project; and the California Food and Fiber Futures Project (CF3).

Tomich says new sustainable-agriculture initiatives under development through the ASI include:

- Developing garden-based learning programs to improve child health and school nutrition.
- Establishing a new UC Davis undergraduate major in sustainable agriculture.
- Attracting "venture capital" for sustainability to help revitalize the SAREP grants program.
- Focusing on science in the public interest through an increased ASI endowment.
- Increasing energy intensity in the food system to help reduce carbon emissions and, in turn, global warming, with the UC Davis Energy Efficiency Center.
- Initiating a California agroecosystem assessment with benchmarks of agricultural sustainability.

"Additional discussions are under way regarding the critical issues of adaptation to climate change, and stewardship of the resource bases that sustain our food system — land, air, water, energy, people and institutions," Tomich says. Tomich is working with the SAREP staff and associated UC and Cooperative Extension personnel, ASI Interim Deputy Director Howard Ferris, eight new ASI-affiliated professorships (four hired, four currently being hired), 150 other UC Davis faculty self-identified as strongly interested in sustainable agriculture, and 150 members of UC Davis Students for Sustainable Agriculture.

ANR strategic direction

About the same time that ASI was founded, ANR formally adopted sustainability as a strategic direction. ANR has sponsored programs related to agricultural sustainability for several decades, such as SAREP, started in 1987, and the Statewide Integrated Pest Management (IPM) Program, started in 1979.

"Even though we haven't always used the term 'sustainable,' our efforts have helped growers provide adequate and dependable farm incomes, protect and enhance natural resources, reduce the use of nonrenewable resources and promote the economic viability, health and quality of life of local communities," says Rick Standiford, ANR acting vice president.

"The time was ripe for the formation of the Agricultural Sustainability Institute," Standiford adds. "University researchers are keenly interested in the serious science behind the concept of sustainable agriculture. We see great opportunities in the joint management of the systemwide SAREP program and the emerging programs of the ASI."

- Lyra Halprin and Editors

For more information:

UC Davis Agricultural Sustainability Institute http://asi.ucdavis.edu/

UC Sustainable Agriculture Research and Education Program http://www.sarep.ucdavis.edu/

> UC Statewide IPM program http://www.ipm.ucdavis.edu

Teaming up helps bring down childhood overweight

The statistics are alarming: the prevalence of overweight children has tripled over the last 30 years, and now affects one in six school-aged children nationwide. But while the problem is plain to see, the remedy has been elusive. Recent studies by UC researchers and others reveal that the rise in childhood obesity is rooted in fundamental social changes, explaining why this epidemic is so hard to control as well as bringing us closer to a solution.

"We used to think the primary cause was parenting, then we thought it was genetic," says Pat Crawford, co-director of UC Berkeley's Center for Weight and Health. "But neither could explain the rapid increase in childhood obesity — we found that a significant fraction is environmental."

Children are considered to be overweight when their body mass index (weight divided by height squared) is at or above the 95th percentile for their age. Half of overweight children continue to be overweight as adults, increasing their risk of illnesses including diabetes, cardiovascular disease and asthma (see page 119).

Environmental changes

Weight gain is a simple equation of calories consumed minus calories burned. But achieving a healthy weight is not so easy these days, when there are more opportunities for eating than for exercising (see page 112).

The changes in children's lifestyles have been particularly acute. Compared to the early 1970s, families today spend about twice as much on eating out, and children ingest almost twice as many calories when they eat in restaurants as when they eat at home. While this change bumps up the "calories consumed" part of the equation, other changes bring down the "calories burned" part. "We spend lots of time sitting in cars and at desks," says Susan Babey of the UCLA Center for Health Policy Research. "And we can't walk to many places." Today only a quarter as many children walk or bike to school compared to a few decades ago.

The impact is worst in the poorest neighborhoods, where children are most likely to be overweight (see page 106). For example, as the number of low-income households rises, teens' access to safe parks and physical activity levels drop, according to a March 2007 UCLA Health Policy Research Brief co-authored by Babey. Other neighborhood characteristics linked to low physical activity in teens include high unemployment and household overcrowding.



Since the 1970s, children have been consuming more calories and getting less exercise. The result has been an epidemic of childhood overweight.

While home environments can be difficult to change, children can also be reached through schools. Unfortunately, many physical education classes today aren't really that physical. For every half-hour of P.E., children are vigorously active for only 4 minutes, according to a January 2007 policy brief commissioned by The California Endowment and co-authored by Toni Yancey, co-director of the UCLA School of Public Health's Center to Eliminate Health Disparities. Again, the impact is worst in the poorest communities.

Besides contributing to children's low physical activity levels, schools are exacerbating the other part of the weight-gain equation. UC studies have shown that many schools are full of fast food and soda, tempting children to consume too many empty calories (see page 124).

Can legislation help?

Now UC researchers are evaluating California legislation designed to fix this problem, such as SB 281, which mandates more fresh fruits and vegetables at school breakfasts. Encouragingly, offerings of fresh fruit have more than doubled, according to a preliminary study by the Center for Weight and Health.

"Promoting fresh produce is good for children's health and for the California economy." says Gail Woodward-Lopez, the center's associate director.



Community leaders participating in the Children and Weight Coalition of Solano County (see page 124) learn about how they can encourage families and children to adopt healthier lifestyles.

The Center for Weight and Health is also evaluating SB 12, which limits school sales of high-fat and high-sugar foods beginning this summer, and SB 965, which completely phases out school sales of soda and other high-sugar beverages over the next 2 years in California. "We will be assessing factors such as the extent of implementation, challenges school districts face and students' dietary intakes," Woodward-Lopez says.

Community-based approaches

Organizations are also trying to reach children outside of school via community health initiatives. These include two initiatives with almost identical names, which is not surprising considering that they also have similar goals: Healthy Eating Active Living (HEAL), which is sponsored by Kaiser Permanente (see page 124); and Healthy Eating, Active Communities (HEAC), sponsored by The California Endowment, a private health foundation with additional funding from Kaiser Permanente.

UC is part of a team evaluating HEAC in six California communities, with UCLA focusing on physical activity and UC Berkeley on nutrition. The Center for Weight and Health is also part of the team evaluating HEAL in three California communities. "These are the first comprehensive, communitywide interventions of their kind," Crawford says.

To further inform efforts to promote healthy eating and exercise habits among children, UCLA researchers are updating their evaluation of the status of childhood obesity statewide. This will include monitoring weight trends and assessing the many factors implicated in the rise in obesity. The update is part of the California Health Interview Survey, which has been conducted every 2 years since 2001 by the UCLA Center for Health Policy Research, the California Department of Health Services, and the Public Health Institute, a national nonprofit organization.

All the pieces come together at the California Childhood Obesity conferences, which focus on preventing excess weight gain in children. The conferences are organized by the Center for Weight and Health, the California Department of Health Services, the California Department of

Education, and The California Endowment. Since the first conference in 2001, to the most recent one held earlier this year in Anaheim, the participants have expanded from nutritionists and health care professionals to also include educators, city planners, and park and recreation officials.

Involving everyone is crucial to stopping and maybe even reversing the childhood obesity epidemic. "We can't say there are too many factors, that it's too complex," Crawford says. "If we don't act, the rate of childhood obesity will be quadrupled soon." — Robin Meadows

For more information: UC Berkeley Center for Weight and Health http://nature.berkeley.edu/cwh



by Patricia B. Crawford, Cathi L. Lamp, Yvonne Nicholson, Sarah Krathwohl, Mark Hudes and Marilyn S. Townsend

RESEARCH ARTICLE

The purpose of this study was to examine the associations between past and current maternal food insecurity and child-feeding practices among low-income Mexican-American families. Participants in the study were mother-child pairs enrolled in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC). The findings suggest that low-income Mexican-American mothers who are currently experiencing food insecurity were more likely to worry that their children were eating too much food and tended to offer smaller portion sizes to their children than mothers not currently experiencing food insecurity. Mothers who were overweight were more than twice as likely to have overweight children than mothers who were not overweight.

While excess weight is a concern across nearly all age levels in the United States, the emergence of pediatric overweight at earlier childhood ages is of particular concern due to its association with type 2 diabetes and chronic disease risk. Among children from 2 to 5 years old, the prevalence of overweight rose from 7% to 10% over the last decade (NCHS 2004). Moreover, there are ethnic disparities in the prevalence of childhood overweight (Crawford et al. 2001). In this age range, Mexican-American children were more likely to be overweight than those who were non-Hispanic black or non-Hispanic white (13% versus 9%, respectively) (NCHS 2004).

Rates of excess weight and obesity are also higher within low-income



To better understand how mothers may influence their child's eating habits and weight, the authors studied pairs of low-income Latino mothers and their young children. This mother and daughter enjoying lunch were not study participants.

populations. Paradoxically, this is the same socio-demographic group that is affected by food insecurity (Crawford, Townsend, et al. 2004). The prevalence of food insecurity is highest for Hispanic and African-American households (22%) and households living below the federal poverty level (38%). In 2002, twice as many households with children under 18 years old experienced food insecurity compared to households without children (17% versus 8%, respectively) (Nord 2003). Recent research suggests that food insecurity may play a role in the onset of obesity among some low-income groups (Olson 1999; Kendall et al. 1996).

Child-feeding practices

Assuming that parental childfeeding practices are related to childhood overweight, interventions can focus on modifying these practices in order to prevent obesity in children.

Food restriction. Involuntary food restriction may result in preoccupation with food, overeating and/or disor-

dered eating, and weight gain (Kendall et al. 1996; Townsend et al. 2001). Studies suggest that food deprivation in childhood may induce binge eating behavior and overeating when food is plentiful (Fisher and Birch 1999). Nutrition educators have reported that overeating when food is available is a common food practice for participants in the Expanded Food and Nutrition Education Program (EFNEP) and Food Stamp Nutrition Education (FSNE) program (Kempson et al. 2002).

It is also possible that women who have experienced past food insecurity may practice restrictive feeding in an attempt to accommodate anticipated food shortages. However, this practice may disrupt natural systems of selfregulation. Limiting foods may promote the child's desire for certain foods, causing disregulation of caloric intake, overeating and ultimately excess weight gain. There is consistent data indicating that in noncontrolling, noncoercive households where children have access to a wide variety of healthy foods, chil-



Mothers were shown pictures of different portion sizes for a variety of foods, in order to assess the typical amounts served to their children. Mothers currently experiencing food insecurity generally offered smaller portions of certain foods, such as French fries and chicken nuggets.

dren have the ability to self-regulate the amount of food and energy consumed (Johnson 2000).

Emotional feeding. Children's overeating may be associated with the childfeeding practice known as "emotional feeding"; for example, a parent may give a child something to eat to make him feel better or may use food as a reward. Food may be an index of caring attention in Mexican families, with parents indulging their children through sweet treats and snack foods (Brewis 2003).

Portion sizes. Increasing portion sizes have paralleled obesity increases over the last 3 decades. There is evidence that portion sizes are increasing even for children as young as 1 to 2 years old (McConahy et al. 2002). Studies have shown that more calories are consumed when larger portion sizes are offered (Engell et al. 1995; Rolls et al. 2002). Examining experiences of food deprivation and insecurity may be informative to understanding perceptions sizes.

Food insecurity, child-feeding study

To examine these issues, a study was designed to assess the impact of maternal food insecurity, both past and current, on child-feeding practices that are associated with weight gain among children in low-income families enrolled in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC). Three main research questions guided the study. First, are mothers who are currently experiencing food insecurity or who have experienced food insecurity in their past more likely than other mothers to: (A) be indulgent with respect to feeding their child, (B) control or restrict their children's food, (C) use food as a reward or (D) offer their children larger portion sizes? Second, are mothers who are overweight or obese themselves more likely to engage in these child-feeding practices? Third, are mothers who engage in these childfeeding practices more likely to have children who are overweight?

Glossary

Adiposity: Body fatness, specifically the body-fat tissue.

Food insecurity: Limited or uncertain availability of a safe and nutritionally adequate food supply.

Food security: Access to a relatively stable, safe and nutritionally adequate food supply.

Overweight and obesity (adults): Excess body weight as defined using height and weight indicators. Adults with a body mass index (BMI) over 25 (kg/m²) are considered overweight; those with a BMI over 30 are defined as obese.

Overweight (children): For children, overweight status is defined using sex- and age-specific growth charts developed by the Centers for Disease Control and Prevention, with "at risk" for overweight being defined as a BMI between the 85th and 95th percentile, and overweight being defined as a BMI that is more than the 95th percentile.

Participants. Subjects were recruited from WIC participants in two California counties: Tulare, which is in the Central Valley and is rural, and Sacramento, which is urban. WICeligible Latino mothers of children 3 to 5 years old were invited to participate at the time of their regularly scheduled WIC visit. All study participants signed an informed consent form. Participants were told that their participation or nonparticipation would have no effect on their WIC enrollment or benefits. As an incentive, each participant received a \$10 gift card from Save Mart or Target.

Working in collaboration with WIC, two bilingual Cooperative Extension staff members interviewed each participant. Interviews were conducted in person, in Spanish or English, at the local WIC office or community multiservice health clinic. Anthropometric data and questionnaires concerning feeding practices and food insecurity were collected and analyzed for 74 mother-child pairs. We also collected the questionnaires but not anthropometric data for an additional 49 motherchild pairs, for a total of 123 pairs of mothers and children.

Data collected. We used six measurement tools for this study.

(1) The **participant screener** was used to identify and exclude mothers who were pregnant or postpartum, or who had children with physical disabilities.

(2) The **demographic enrollment form** captured basic information including the mother's date of birth, birthplace and childhood home, language spoken in the home, level of education and household income.

(3) The Child Feeding Practices **Questionnaire** included 21 questions related to restriction/maternal control, indulgence, food as a reward and other child-feeding behaviors. This instrument was adapted from one developed and validated by Birch et al. (2001). Questions related to restriction/maternal control included: "Do you scold your child for not eating well?" and "I have to be sure that my child does not eat too many sweets." Questions related to indulgence in child feeding included: "If your child does not want to eat at mealtime, do you offer other foods?" and "Does your child take food from the refrigerator, or a shelf, for a snack whenever she/he is hungry between meals?" Questions related to using food as a reward included: "I offer my child his/her favorite foods in exchange for good behavior" and "How often do you give your child food to keep him/her quiet?"

Questions were added to assess the portion sizes of specific foods that mothers serve to their children. This tool included 17 sets of photographs of foods in bowls, to provide a physical reference for portion size. Each set contained two to six photographs of varying portion sizes of a particular food. For each food, the range of portion sizes was developed based on the daily serving size recommended for 2 to 6 year olds in the USDA Food Guide Pyramid for Young Children (USDA 1999). The food portions portrayed were ranked on a four-point scale. Based on these photographs, participants were asked

to choose the serving size that most accurately corresponded to the amount they feed their child. The corresponding weight of the selected portion size was then recorded in grams. This tool was validated by comparing subjects' responses to their child's food intake, as measured in a 24-hour recall. A nominal correlation was found between mother's preferences for offering larger serving sizes and child's total energy intake ($\mathbf{r} = 0.18$, P = 0.1068).

(4) The USDA Food Security/Hunger Core Module Questionnaire (Bickel et al. 2000) was administered to assess current food insecurity in households. This instrument includes screener questions and an 18-item food-security measurement scale.

(5) The **Past Food Insecurity Questionnaire**, which was developed by this research team (Crawford, with an electronic scale. Shoes and outer clothing were removed for the height and weight measurements.

For mothers, a BMI between 25 and 30 was defined as being overweight, and a BMI of 30 or more was defined as obese. For children, those with a BMI greater than or equal to the 95th percentile using sex- and age-specific growth charts developed by the Centers for Disease Control and Prevention were categorized as overweight. Children with BMIs between the 85th and 95th percentile were classified as "at risk for overweight." The advantages of using BMI to measure adiposity include its reliability, noninvasiveness, affordability and ease of calculation.

Prior to data collection, UC Cooperative Extension staff from Sacramento and Tulare counties attended a training and certification

Fewer than a third of the mothers with overweight children perceived their child as being overweight or heavier than children the same age.

Townsend, et al. 2004), includes 10 dichotomized (yes/no) questions about the level of food security the mother experienced as a child. The construct validity of this instrument was determined based on correlations with the size of the mother's childhood household and past food insufficiency. A household is considered food insufficient if household members sometimes or often do not have enough to eat (Ribar and Hamrick 2003). Past food insecurity was strongly correlated with household size (r = 0.31, P < 0.003) and food insufficiency (r = 0.70, *P* < 0.0001), which were the comparative measures for validation.

(6) **Height and weight measurements** were assessed for both mothers and children. This data was used to calculate body mass index (BMI), which is defined as body weight in kilograms divided by the square of height in meters (kg/m²). Height was measured to the nearest 0.1 centimeter using a portable stadiometer with a fitted headpiece. Body weight was measured to the nearest 0.1 kilogram

program to standardize data collection procedures across the two study sites. In accordance with study protocols, one of the two bilingual data collectors administered the data collection instruments to each mother during an interview lasting approximately 1 hour. The Center for Weight and Health at UC Berkeley processed data from the questionnaires.

Statistical analyses. For each of the research questions, the dependent variables were child-feeding practices and portion-size perceptions. Based on established methods (Carlson et al. 1999), responses to the USDA Food Security/ Hunger Core Module were dichotomized, and a participant responding affirmatively ("yes," "often" or "sometimes") to fewer than three of 18 questions was categorized as "food secure," while those responding affirmatively to three or more were categorized as "food insecure." To assess past food insecurity, participants who gave three or more positive responses to the 10-item Past Food Insecurity Questionnaire

were categorized as "past food insecure," and those responding affirmatively to fewer than three were categorized as "not past food insecure."

To examine the relationship between child-feeding practices, past and current maternal food insecurity, and child's weight, Wilcoxon Rank Sum tests were used to test these associations among most of the variables. For variables that were dichotomous, chisquare tests were used. Chi-square analyses were used to evaluate the relationship among pairs of the following categorical variables: dichotomous children's BMI, mother's BMI, and past and current food insecurity.

Relationships and trends

Mother's demographics. Most of the 123 participating mothers were recent immigrants from Mexico: 118 were born and 112 grew up there. Only eight grew up in the United States, and two had missing data. Ninety percent of the mothers reported speaking Spanish at home. The mothers' ages ranged from 20 to 50 years, with a median age of 29 years. Forty-three percent of the participants had 8 or fewer years of education, while the remaining 57% had from 9 to 12 years. Nearly all (94%) reported monthly household incomes of \$2,000 or less.

Children's weights. Twenty-seven percent (n = 20) of the children in the sample were overweight, with BMIs more than or equal to the 95th percentile for children their age, and there was a strong relationship between mother's BMI and children's BMI (table 1). Mothers with BMIs of 30 or higher were more than twice as likely to have children with BMIs above the 95th percentile than mothers with BMIs below 30 (43% versus 16%, respectively) (P < 0.005).

Interestingly, less than one-third of the mothers with overweight children perceived their child as being overweight or heavier than children the same age. About half of the mothers with overweight children reported that a doctor or other health professional had told them their child was overweight. Sixty-four percent of the moth-



In the study, mothers who were currently food insecure were about twice as likely as those who were food secure to worry about their children overeating. *Above*, a girl eats lunch at a child-care center.

ers with overweight children were not concerned about their child becoming overweight, and 77% were not worried about their child eating too much food.

Food security and child weight. Over half (n = 66) of the 123 participants interviewed had experienced some form of past food insecurity; less than onequarter (n = 26) reported current food insecurity (table 2). Fourteen percent (n = 17) of the participants reported experiencing both past and current food insecurity. While not statistically significant, there appeared to be a trend for those who experienced food insecurity as a child to report current food insecurity (P = 0.18).

Of the 74 mothers who were weighed and measured, the mother's weight was not associated with their level of current food security. Thirty-one percent of those who had experienced past food insecurity were obese (BMI higher than 30), versus 53% of those who had not

TABLE 1. Relationship between weight of mother and weight of child*

	Mother's BMI†		
Child's BMI‡	< 30	≥ 30	Total
		n (%)	
< 95th percentile	37 (84)	17 (57)	54 (73)
≥ 95th percentile	7 (16)	13 (43)	20 (27)
Total	44	30	74
* Chi-square <i>P</i> < 0.01.			

+ BMI = body mass index; ≥ 30 is categorized as obese.

‡ 95th percentile is categorized as overweight.

TABLE 2. Food-security status of all mothers, past and present (n = 123)

	Past		
Current	Food secure	Food insecure	Total
Food secure	48	49	97
Food insecure	9	17	26
Total	57	66	123

experienced past food insecurity (P = 0.054) (data not shown). There was no association between current or past maternal food security or insecurity and their child's weight.

Child feeding and mother's past food insecurity. Although not reaching statistical significance in this small study, a few trends seemed worth noting. Mothers who are currently food insecure may be less likely to keep track of the sweets their children eat (P = 0.069). and less likely to tell their children that they could not go out to play or get up to watch television until they eat (P =0.089). In addition, food-insecure mothers may be more likely to offer their children their favorite foods as a reward for good behavior (P = 0.088). Mothers who were food-insecure in the past may be less likely to believe that their children should always eat all of the food on their plate (P = 0.079).

Food security and child portion sizes. Mothers *currently* experiencing food insecurity seemed to offer their children smaller portions of certain foods such as French fries (P < 0.10) and chicken nuggets (P < 0.05) (table 3). On the other hand, mothers who experienced *past* food insecurity offered their children larger portions of orange juice (P < 0.05) and smaller portions of corn (P < 0.10) (Note: P values below 0.05 are considered statistically significant; P values below 0.10 are considered a statistical trend.)

Child-feeding practices and weight. Child-feeding style did not appear to be associated with mother's weight. The only parental feeding behavior significantly associated with BMI in children was that of mothers of overweight children, who were more likely than the other mothers to report scolding their child for not eating well (P < 0.05).

Concern over weight and food. Mothers who were currently food-insecure were about twice as likely as those who were food-secure to worry that their child eats too much food (42% versus 18%, respectively) (P < 0.01). About four times as many food-insecure mothers reported having been told by a physician or health professional that their child was overweight compared to mothers who are currently food TABLE 3. Relationship between some portion sizes and current and past maternal food insecurity

	Food ins	ecurity
Food portion (range of sizes)	Current	Past
	· · · · · · P value (di	rection)*·····
Orange juice (½ to 1¼ cup)	0.691 (–)	0.002† (+)
Corn (¼ to 1 cup)	0.155 (–)	0.096 (–)
French fries (38 to 101 grams)	0.085 (–)	0.422 (–)
Chicken nuggets (45 to 150 grams, or 3 to 10 pieces)	0.045† (–)	0.184 (–)
* Sign in parenthesis indicates direction of association, with a mi	nus	

Statistically significant at P > 0.05.

secure (27% versus 6%, respectively). Forty-three percent of the children of food-insecure mothers were classified as overweight (BMI greater than the 95th percentile). As expected, mothers of overweight children were more likely to report being concerned that their child eats too much (P = 0.029). Accordingly, these mothers were much more likely to be concerned about child overweight (P < 0.001).

Addressing childhood overweight

There were 60% more overweight children in our study population (27%) than found in other national studies for low-income Latino children (17%) (Polhamus et al. 2004). However, by definition our convenience sample of WIC-eligible urban and rural mothers of 3-to-5-year-old Latino children from two California counties was not representative.

Among Latino immigrants such as the young Mexican-American mothers in our study, acculturation to U.S. culture is associated with poor dietary habits, less physical activity and high rates of obesity (Ravussin et al. 1994; Unger et al. 2004). Subsequent generations of Latinos in the United States tend to increase their consumption of fast food, convenience foods, salty snacks, simple sugars, chocolate candy, and total added and saturated fats (Ayala et al. 2005; Neuhouser et al. 2004).

Because children's eating habits are largely developed and maintained in the home, parental feeding practices are of particular concern. While not statistically significant, mothers who were experiencing food insecurity tended to be less likely to use restrictive child-feeding practices and more likely to use food as a reward. At the same time, these mothers were more likely to worry that their child was eating too much food (P < 0.01). Accordingly, these mothers tended to be more likely to offer smaller portion sizes to their children. Others have reported that current food insecurity may affect the variety of foods available and consumed by families (Kaiser et al. 2003). It seems natural for mothers to limit foods in times of food insecurity, and to offer more when food is available. Our observations indicate that *current* food insecurity, as compared to past food insecurity, is more associated with child-feeding practices and weight status.

In our sample, we found few parenting differences between mothers with past or current food-insecurity. However, our study was limited by the small sample size. Even so, we did find trends among mothers with past food insecurity that suggest possible differences in factors associated with obesity. For example, past food-insecure mothers were less likely to be obese than mothers who had not experienced food insecurity in their childhoods (P = 0.054). In contrast to other studies showing a significant association between food insecurity and obesity in Latino mothers (Crawford, Gosliner, et al. 2004), we found that mothers who were currently food-insecure were no more likely to be obese than currently food-secure mothers.

The failure of many mothers to recognize that their children were overweight is an important finding. Studies have shown that Latino mothers associate thinness with poor health and being prone to disease ► UC nutrition educator Dolores Vallejo (left) and Angie Tazio, nutrition education program manager, demonstrate how they conducted the portion-size part of the study, which found that current food insecurity was more closely associated with child-feeding practices than past food insecurity.

(Crawford, Gosliner, et al. 2004). Other studies of food insecurity among Latino immigrants have confirmed the mismatch between excess weight in children and maternal concern. WIC mothers have been observed to disagree when educators identify their children as overweight (Chamberlin et al. 2002). It is possible that in a setting where such a high percentage of children are overweight, mothers may assume that higher weight levels are the norm. Furthermore, mothers may be reluctant to label or believe that their children are overweight (Myers and Vargas 2000). Finally, Latino mothers have suggested that their child will "grow out of it" or is genetically destined to be large (Crawford, Gosliner, et al. 2004).

This is the first study to examine associations between current and past food insecurity and child-feeding practices. The importance of studying this population is immense, due to the greater incidence of overweight and diabetes in low-income Latino children. While the issue of child overweight has received much attention, this UC Cooperative Extension study can help to elucidate appropriate intervention strategies, laying a foundation for teaching parents of preschoolers about the relationships between childhood obesity and child-feeding practices.

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Preventing obesity: What should we eat?

by Lorrene D. Ritchie, Gail Woodward-Lopez, Dana Gerstein, Dorothy Smith, Margaret Johns *and* Patricia B. Crawford

To curb the escalating rates of obesity in California and across the nation, it is imperative to identify dietary behaviors that prevent excessive weight gain. Reports in the press are often conflicting and more often confuse than clarify the issue of what people should eat to prevent obesity. We recently conducted a comprehensive review of the literature published between 1992 and 2003 on the dietary determinants of obesity in children and adults. We examined secular trend data, mechanistic research, observational studies and prevention trials. We found that the dietary factors related to increased obesity were high intakes of dietary fat, sweetened beverages and restaurantprepared foods, and the increased likelihood of skipping breakfast. Factors most likely to protect against obesity were the higher consumption of dietary fiber, fruits and vegetables, calcium and dairy products.

The rapid rise in body weight of Americans has led top health officials to label obesity a national crisis. Since the 1970s, the prevalence of obesity has doubled among adults and tripled among children in the United States (CDC 2002). California is not exempt from this crisis. In 2001, more

Editor's note: Detailed methodology and background information for research supporting some conclusions of this review article can be found in Obesity: Dietary and Developmental Influences (Woodward-Lopez et al. 2006) and "Family environment and pediatric overweight: What is a parent to do?" (Ritchie et al. 2005).



An analysis of thousands of peer-reviewed obesity and nutrition studies published between 1992 and 2003 found that fruits and vegetables contribute to weight maintenance, because they are simultaneously low in calories and filling.

than 4.7 million Californians, or 19% of all adults, were obese (Lund et al. 2004). Obesity increases the risk of myriad health problems, including type 2 diabetes, cardiovascular disease, renal and liver disease, gastrointestinal disorders and certain forms of cancer. Managing obesity-related health problems is a major burden to the state and national health-care systems. The high costs and limited success of treating obesity that has already developed make prevention essential. However, efforts to design effective dietary interventions have been stymied by conflicting and inadequate understanding of the multiple causes of obesity.

The rising rates of obesity are paralleled by a marked increase in the amount of research being conducted (fig. 1). However, the need for synthesis of research findings and the development of action recommendations is critical. The purpose of this article is to distill the research on key dietary factors that are crucial for inclusion in community nutrition-intervention programs designed to prevent obesity (see page 124). These factors and the extensive supporting literature are drawn primarily from Woodward-Lopez et al. (2006) and Ritchie et al. (2005), and these references provide detailed methodology and background information on the studies that support the conclusions in this review. Although physical activity and sedentary behavior also play a role in the development

TABLE 1. Inclusion and exclusion criteria used in selection of articles to review

Exclusion criteria

of obesity, the focus of this review is on the role of dietary factors.

Analyzing the evidence

To understand emerging evidence on the dietary determinants of obesity, we recently completed a 3-year project to systematically review the scientific literature. This review was conducted under the guidance of the Obesity Prevention Network (OPN), convened by the Centers for Disease Control and Prevention. Reviewers with expertise in nutrition and/or obesity included researchers from seven universities and representatives from 12 state health departments across the country. Relevant studies published between 1992 and 2003 were identified from a search of the PubMed database, as well as from studies cited in other research papers and review articles. Specified search terms were utilized according to the topic of interest. For example, for the topic "sweetened beverages," search terms included *obesity*, soda, soft drinks, sweetened beverages and fruit drinks.

Specific inclusion and exclusion criteria were adhered to in the selection of articles to review (table 1). The focus was on studies of humans, both children and adults. Each selected article was abstracted on an article review table by an OPN member in order to systematically collect information about sample size and demographics, sampling strategy, study



Fig. 1. Scientific publications on obesity since 1975, based on PubMed search of Englishlanguage publications that included an abstract.

Inclusion criteria

- Studies reporting on secular trends with regard to the determinant of interest covering at least a 6-year period since 1975
- Experimental and other types of studies designed to elucidate the relationship between the determinant of interest and adiposity
- Observational studies that examined the relationship between the determinant of interest and some measure of adiposity
- Interventions aimed at modifying at least one of the determinants of interest, with the aim of preventing weight gain, improving health or preventing chronic disease, but not designed to promote weight loss
- Intervention studies whose primary outcome was a change in a health index other than adiposity (for example, blood pressure, total cholesterol), as long as adiposity was also measured and examined in the analysis
- Reviews that covered the types of studies listed above

- Weight loss studies that: (1) examined weight loss interventions; (2) specifically targeted caloric restrictions at levels intended to promote weight loss; or (3) included only overweight and/or obese subjects
- Training studies, conducted among trained athletes
- Prevention trials or observational studies that did not include a measure of adiposity (for example, body weight, body mass index, skin folds, percentage body fat)
- Studies of populations with chronic diseases, such as diabetes
- Studies published only in abstract form or in journals that are not peer-reviewed (with the exception of some food intake or disappearance data available from the federal government)
- Studies conducted in developing countries

design and duration, statistical analysis, control variables, assessment of independent and dependent variables, and study findings, strengths and limitations.

We examined four lines of evidence with respect to each dietary factor: (1) secular trends data, documenting changes in a determinant in the United States over the period that obesity has risen most steeply — since the mid-1970s; (2) mechanistic research that examined either a characteristic of a food, such as palatability or satiability, that is likely to affect energy intake; or experimental studies that examined how a diet-related factor might affect total energy intake; (3) observational studies in free-living (i.e., not in a laboratory setting) populations that examined the relationship between a diet-related factor and an outcome measure of adiposity, such as body mass index (BMI), body fat or waist circumference; and (4) prevention trials aimed at intervening with weight gain or the development of chronic disease that included a measure of adiposity but were not designed specifically to promote weight loss or treat obesity (table 2).

For each dietary topic, an evidence analysis group was formed of OPN members. For each line of evidence, the group addressed the number and merits of the studies reviewed and answered the question, "Does the preponderance of the examined evidence, based on strength and consistency, support that dietary factor X is a determinant of obesity?" For each line of evidence, this question was answered *yes, no, inconclusive* or *no studies*, based on specific criteria. A more detailed description of the methods and findings, including a discussion of the merits and limitations of the studies reviewed in arriving at conclusions, can be found in Woodward-Lopez et al. (2006).

What the evidence tells us

Energy density. The consumption of excess energy — in relation to needs — leads to weight gain. Since the mid-1970s, per capita energy intake in the United States has substantially increased (Troiano et al. 2000; Putnam et al. 2002). Energy density, the number of calories in a given weight of food, is one metric that is used to distinguish between foods with higher and lower energy contents. Our current food supply abounds with energy-dense, nutrient-poor foods — typically highly processed foods that contain relatively large amounts of fat and/or sugar. Nearly one-third of the total energy intake among adults comes from these foods, and the more energy-dense the

TABLE 2. Summary of the nature and consistency of evidence for selected dietary factors in relationship to obesity*

			Line of	evidence		Concl	usion
Dietary factor	No. observational studies/ prevention trials	Secular trends	Mechanistic research	Observational studies	Prevention trials	Preponderance of evidence	Recommendation for obesity prevention
Energy density	4/0	Inconclusive	Yes	Inconclusive	No studies	Inconclusive	—†
Dietary fat	75/24	No	Yes	Yes	Yes	Yes	Decrease consumption
Total carbohydrate	51/9	No	Yes	Yes	Yes	Yes	—
Dietary fiber	15/10	No	Yes	Yes	Yes	Yes	Increase consumption
Simple sugars	11/1	Yes	Yes	Inconclusive	Inconclusive	Inconclusive	_
Sweetened beverages	10/2	Yes	Yes	Yes	Inconclusive	Yes	Decrease consumption
Fruits and vegetables	32/8	No	Yes	Yes	Inconclusive	Yes	Increase consumption
Fruit juice‡§	9/0	No	Yes	No	No studies	Inconclusive	_
Calcium	11/21	Yes§	Yes	Yes	Inconclusive	Yes	Increase consumption
Dairy products	16/10	Yes¶	Yes	Yes	Inconclusive	Yes	Increase consumption
Eating out	13/0	Yes	Yes	Yes	No studies	Yes	Decrease consumption
Variety of foods	5/1	Yes	Inconclusive	Inconclusive	Inconclusive	Inconclusive	_
Portion size	1/0	Yes	Inconclusive	Inconclusive	No studies	Inconclusive	—
Eating frequency	17/1	Yes	Inconclusive	Inconclusive	Inconclusive	Inconclusive	—
Snacking	22/1	Yes	Yes	Inconclusive	Inconclusive	Inconclusive	—
Skipping breakfast	16/0	Yes	Inconclusive	Yes	No studies	Yes	Decrease behavior

* Based on the number and nature of studies, yes signifies an affirmative and no a negative response; inconclusive signifies that neither an affirmative nor a negative response was appropriate based on the preponderance of evidence available; no studies signifies that a response to the question was not possible because no relevant studies were available.

t No recommendation given if the preponderance of evidence does not support a positive or negative relationship with the given dietary factor.

‡ 100% fruit juice.

§ Children only.

¶ Milk only.

diet, the higher the total energy intake tends to be (Kant 2000).

However, at present it is not possible to conclude that manipulating the energy density of the diet would be an effective strategy for preventing obesity. This is because of assessment difficulties and the use of variable methods to calculate energy density (for example, the inclusion of all foods and beverages versus the inclusion of only energycontaining foods), and mixed findings (showing no relationship or a positive relationship) from the limited number of observational studies on energy density in relation to weight status.

Dietary fat. A majority of the U.S. population consumes fat in excess of U.S. dietary recommendations for health; only about one in three Americans met the 2000 dietary guideline of less than 30% of calories from fat (Kennedy et al. 1999; Troiano et al. 2000). (As of 2005, the dietary guideline for fat was 20% to 35% of calories; previous editions of the dietary guideline recommended no more than 30% of calories from fat.) Mechanistic studies show that dietary fat, because of its high caloric content, palatability, and efficient utilization and storage, may be more problematic for weight maintenance than other macronutrients (Parsons et al. 1999). The preponderance of evidence from both observational studies and intervention trials further supports the conclusion that the consumption of high-fat foods is a risk factor for excessive weight gain.

Carbohydrate, fiber, sugar. Carbohydrates are a heterogeneous group of food components ranging from simple sugars (such as sucrose and fructose) to complex carbohydrates (such as dietary fiber). Carbohydrates are not alike with respect to obesity risk. Although the intake of most types of carbohydrates, including dietary fiber, has risen concurrently with total food intake in recent years (Enns et al. 1997), the preponderance of evidence suggests that dietary fiber may be beneficial in abating obesity. Carbohydrates in general, and dietary fiber in particular, are more satiating or filling and less energy-dense than dietary fats (Stubbs et al. 2000). Further, observational studies have consistently found that obesity is less prevalent with higher fiber intake.

Contrary to popular perception, the evidence on simple sugars, another form of carbohydrate, is more complicated and less conclusive than for dietary fat or fiber. Although experimental studies suggest that simple carbohydrates are readily overconsumed, in observational studies total sugar intake is either not associated with obesity or is negatively associated, meaning that thinner people tend to eat more simple sugars than fatter people. However, there is considerable evidence that some forms of sugar in the diet are indeed problematic.

Sweetened beverages. Calorically sweetened beverages are a leading source of sugar in the typical American

diet, and the consumption of them has risen dramatically in recent decades (Jacobson 2001). Per capita consumption of soft drinks alone has increased from approximately 10 gallons per person in the 1940s to 60 gallons per person in the 1990s (Gerrior et al. 1998). Physiological compensation for energy consumed as a liquid appears to be less complete than when the same amount of energy is consumed as a solid food (Mattes 1996), so that consumption of sugar in beverage form is likely to result in higher total energy intake (Harnack et al. 1999). Also, fructose in the form of high-fructose corn syrup, which is commonly added as a sweetener in beverages, has emerged recently as a potential contributor to energy imbalance because of the way in which it is metabolized in the liver to favor lipogenesis. Fructose also fails to stimulate endocrine pathways that are known to regulate food intake and energy homeostasis (Havel 2001).

Substantial observational evidence also points to calorically sweetened beverages as a culprit in the obesity epidemic. In a study of school-aged children, each additional serving of a sweetened beverage consumed daily over a 1.5-year period increased the risk of becoming overweight by 60% (Ludwig et al. 2001). More recently, in a study published after our review, a 1-year, school-based intervention in the United Kingdom that decreased the consumption of soft drinks by only one-third-cup per day resulted in a 7% reduction in overweight compared to children in the control group (James et al. 2004).

Fruits and vegetables. Fruits and vegetables may contribute to weight maintenance because of their low energy content and high satiety value. Although per capita vegetable and fruit intake has increased slightly since the 1970s (Putnam et al. 2002), only 41% of the population meets the recommendation for three to five daily servings of vegetables (GAO 2002). Further, more than one-third of what counts as vegetables in the U.S. food supply consists of iceberg lettuce, frozen potatoes (mostly French fries) and potato chips (Putnam et al. 2000). Observational evidence also supports that fruit and vegetable intake protects against obesity. The finding that fruits may be more protective than



Fast foods are typically higher in calories and fat, while lacking essential nutrients. Current data indicates that eating out more often increases the risk of weight gain. *Above*, a food stand at the California State Fair in Sacramento.

vegetables may be a function of how fruits and vegetables are typically consumed. The benefits of vegetables, for example, may not be attained if they are typically consumed with large amounts of fat added during frying or topped with high-fat dressings, sauces or condiments (Lin and Morrison 2002).

Fruit juice. Fruit juice was examined separately from total fruit intake because it is a source of liquid calories and fructose and, by the same mechanisms as proposed for calorically sweetened beverages, could presumably contribute to excess energy intake and storage. On a populationwide basis, however, the excessive consumption of fruit juice is not nearly as common as the excessive consumption of calorically sweetened beverages. On a daily basis, Americans consume the weight equivalent of roughly four times more carbonated soft drinks than all types of fruit juice combined. Fruit juice intake has not changed substantially since the 1970s, during which time obesity has risen most steeply (Putnam and Allshouse 1999). This fact, together with a preponderance of observational data showing no relation between fruit juice intake and obesity, supports the

conclusion that fruit juice is not a critical behavior to target for obesity prevention. All of the observational studies that we examined on fruit juice intake in relation to obesity involved children only. However, because fruit juice intake tends to decrease as children get older, the excessive intake of fruit juice is an unlikely determinant of obesity in adults (Demory-Luce et al. 2004).

Calcium and dairy products. Milk intake has decreased in recent decades,

In 2001, more than 4.7 million Californians, or 19% of all adults, were obese.

while the intake of cheese has increased. The mechanism whereby dairy intake might be related to weight has not been clearly established. There may be a biological effect on the energy balance of calcium or another component in dairy; an avoidance of dairy by overweight individuals concerned about additional weight gain; and/or a replacement of fluid milk with soft drinks and other calorie-containing beverages. There is some evidence that a high intake of calcium can influence energy balance by reducing adipose cell storage of fat and increasing fecal fat losses (Zemel et al. 2000). Other biologically active components in dairy may have additive effects. The preponderance of observational data supports the hypothesis that a low intake of dietary calcium and dairy is related to higher adiposity. Although the differential effects of low-fat and nonfat versus high-fat sources of dairy have not been well studied, the increased consumption of low-fat dairy products and calcium-rich foods is consistent with recommendations for the prevention of cardiovascular disease and the promotion of bone health.

Eating out. Eating out is increasingly the norm. In the 1970s, U.S. households reported spending 20% of food dollars on foods eaten away from home. By the 1990s, that number had nearly doubled (Schwenk 1995). Patrons are often encouraged to purchase meals that contain more calories through "value" marketing or "super-sizing," and restaurants are serving much larger portions. For example, in 1957 a typical hamburger from a fast-food restaurant weighed approximately 1 ounce, compared to up to 6 ounces in 1997. An 8-ounce soda typically served in 1957 now weighs in at 32 to 64 ounces (Nicklas et al. 2001). Further, fast food and restaurant foods are typically high in calories and fat, lacking in other essential nutrients, and highly palatable (Schwenk 1995; Jeffery and French 1998). Although additional studies are needed that use a standardized definition of fast food and eating out, the observational evidence to date suggests that the more one eats out, the harder it is to avoid weight gain.

Variety of foods. Variety is defined as the inclusion of many foods in the diet that differ in one or more sensory qualities, such as color, taste or texture (Raynor and Epstein 2001). Eating a variety of foods has long been recommended as critical to achieving nutrient adequacy (Westenhoefer 2001), but it has also been implicated as one of the factors that encourage restaurant patrons to overeat. Short-term laboratory studies in humans indicate that increasing the variety of foods offered results in greater food, and consequently energy, intake (Jeffery and French 1998).

The variety of foods available in the United States has increased dra-



matically in recent years. In 1970, the number of new food products introduced into the marketplace was a little over 1,000; by 1996 that number had increased to over 13,000 (Gallo 1997). The majority of new food products are energy-dense, nutrient-poor foods like candy, snack foods and bakery items, rather than fruit and vegetable products (Young and Nestle 2002). However, most epidemiological studies of dietary variety have focused on the variety of healthful foods and have not examined influences on weight status. The scant few studies that compared variety of the diet to obesity in humans have had inconsistent findings, variously showing a positive, a negative or no relationship between dietary variety and adiposity.

Taken together, the evidence available to date suggests that the influence of dietary variety on energy balance and adiposity depends on how variety is defined and the classification of foods being considered. We hypothesize that a promising strategy for weight management is to restrict the variety of energy-dense, nutrient-poor foods consumed and increase the variety of lowenergy-dense foods, such as fruits and vegetables. However, this hypothesis merits further study before firm recommendations on variety of foods can be decisively adopted.

Portion size. Americans report consuming increasingly large portion

sizes of a majority of foods (Smiciklas-Wright et al. 2003). This trend has been found for foods such as salty snacks, desserts, soft drinks, fruit drinks, French fries, hamburgers, cheeseburgers and Mexican foods, whether consumed at a restaurant or at home (Nielsen and Popkin 2003). Short-term experimental trials in humans have shown that energy intake tends to increase with exposure to large portion sizes of most foods, but there are some notable exceptions (Rolls et al. 2000; Rolls et al. 2002). In one study, the energy intake of a meal increased after the consumption of a high-energydense salad, but decreased after consumption of the same-sized portion of a low-energy-dense salad (Rolls 2003). In this study, the energy density of the salad was manipulated by adding salad dressing and cheese. We hypothesize that there may be an interrelationship between portion size and energy density (the number of calories in a given weight of food), such that it is advisable to decrease the portion size of the most energy-dense foods and increase that of the least energy-dense foods. Unfortunately, the evidence associating portion sizes directly with overweight is limited at present, precluding a conclusive recommendation.

Eating frequency. Paradoxically, small, frequent meals have been recommended both as a way to increase satiety and prevent weight gain, and



as a way to overcome reduced appetite and limit unintentional weight loss. Total eating frequency has risen concurrently with the prevalence of overweight (Cutler et al. 2003). However, interpreting the evidence on eating frequency is complicated by the use of disparate definitions for what constitutes an eating episode. In some studies, only meals were counted, while others included both meals and snacks; what comprises meals versus snacks was not consistently classified across studies. Further, observational studies have had mixed results. A higher number of eating occasions has been associated with increased weight and decreased weight, as well as with no difference in weight compared to a less-frequent eating pattern.

Snacking. The frequency of snacking by Americans has increased since the 1970s (ARS 2000). Snacks tend to be higher in energy density and fat content than meals (Jahns et al. 2001), and high snack consumption has been associated with an increased intake of fat, sugar and calories (McNutt et al. 1997). The preponderance of observational evidence suggests, however, that the frequency of snacking is not associated with obesity. We hypothesize that how frequently a person snacks may be less important than what and how much she or he eats when snacking, but there is presently not enough consistency in the findings to substantiate a decisive conclusion on snacking.

Skipping breakfast. Populationbased surveys have revealed that many people skip breakfast and eat more food later in the day, and that this pattern has increased since the 1970s (Haines et al. 1996; Siega-Riz et al. 1998). Observational studies fairly consistently have found that overweight individuals are more likely to skip breakfast or to eat a smaller breakfast than their leaner counterparts. Although there are few longitudinal studies that examine the relative influence of different types of breakfast (for example, whether having a doughnut for breakfast is better than eating no breakfast at all), the preponderance of evidence suggests that eating breakfast offers some advantage in preventing overweight.

What can be done?

Eating is a complex behavior. Foods vary widely, and those consumed are a result of many factors, including food purchasing and preparation, snacking and meal patterns, and other actions that affect dietary intake. Our approach of systematically examining and weighing numerous lines of evidence on the individual dietary determinants of obesity is consistent with this complexity. Restricting our review to one study type — most often randomized, controlled trials — eliminates the inherent difficulty involved in comparing studies of different designs and may allow the statistical analysis of findings from sev*Far left*, Americans are snacking more than they did in the 1970s, and the snacks they eat tend to be higher in calories and fat than meals.

Left, overweight persons are more likely to skip breakfast or to eat smaller breakfasts than normal-weight persons. In addition to skipping breakfast, research suggests that eating fatty foods, sweetened drinks, restaurant foods and prepared foods all contribute to excessive weight gain.

eral studies to be combined (for example, meta-analyses). The approach used in this review, while more subjective, has the advantage of including a broader array of studies. Examining consistencies across different lines of evidence strengthens any conclusions derived from a single type of investigation.

Based on our examination, no single dietary factor emerges as having an isolated influence on weight status, but rather a pattern of dietary intake appears important for the maintenance of energy balance. The dietary patterns identified as conducive to excessive weight gain include a high intake of dietary fat, sweetened beverages, restaurant foods and prepared foods, as well as skipping breakfast. Dietary factors that protect against excessive weight gain include the consumption of dietary fiber, fruits and vegetables, and calcium and dairy (table 2). Based on existing evidence, we found that the intake of dietary protein, simple sugars and fruit juice, as well as food variety, portion size, frequency of eating, and snacking were not consistently related to obesity. Studies of food variety and portion size in relation to overweight development were particularly limited.

The evidence from studies of children tended to be less conclusive than studies of adults, a finding that may reflect the difficulty in accurately measuring the typical consumption patterns of children, as well as the inherent fluctuations in energy balance that occur during growth. However, given that lifelong dietary habits are in large part established in childhood, and that adult overweight often begins in youth, it seemed most prudent and practicable to draw a single set of conclusions for all age groups, rather than differentiating between children and adults.

Several dietary factors emerged as priorities for future research, based on a promising but inadequate number of studies and/or being part of common dietary recommendations or practice, even though limited evidence currently supports a relationship with adiposity. Longitudinal studies and intervention trials relevant to public health efforts in California were particularly lacking, including studies of the Latino population.

Although researchers continue to gather evidence on obesity prevention, concerned public health agencies and individual practitioners cannot wait to take action. Current evidence suggests that practitioners should encourage breakfast consumption and increased intakes of fruits, vegetables and low-fat dairy foods, along with the decreased consumption of energy-dense, lownutrient foods. Programs that address these dietary practices, along with promoting physical activity and reducing sedentary behaviors, are most likely to be effective in preventing obesity.

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Overweight and obesity are associated with decreased magnesium intake in people with asthma

by Alexandra G. Kazaks and Judith S. Stern

Asthma is a serious health problem that is more prevalent among lowincome persons. The risk of asthma and the severity of its symptoms may be increased by the low dietary intake of magnesium and other nutrients that protect against asthma, coupled with the high energy intakes that result in overweight and obesity. This study compared people with asthma to healthy controls, and showed that total body magnesium stores decreased with increasing weight, as measured by body mass index (BMI). Replacing low-magnesium foods with high-magnesium foods may be a practical, low-cost way to help reduce the risk of obesity and low magnesium status in people with asthma, especially in at-risk, low-income groups.

Asthma is a major cause of illness and disability in the United States, and is a significant public health burden. In 2003, asthma affected an estimated 20 million individuals in the United States. In 2004, the estimated annual costs due to asthma were more than \$16 billion, including the direct costs of physician and hospital visits, and medications, as well as the indirect costs of lost work days and earnings (ALA 2005).

Although asthma affects Americans of all ages, races and ethnic groups, the Centers for Disease Control and Prevention reports that low-income and minority populations experience significantly higher rates of fatalities, hospital admissions and emergency room visits (CDC 2000). While the reasons for these disparities are not clearly understood, factors such as limited access to medical care and lack of self-management skills all contribute to increased asthma symptoms.

The current concept of asthma has shifted from a disease of smooth muscle



The surface of a person's windpipe (photographed with a colored electron-scanning microscope) can trap pollen grains (pink) on hairlike cilia (yellow). In asthmatic or allergic persons, the particles can cause a hypersensitive reaction that leads to breathing difficulties.

dysfunction to one characterized by the persistent inflammation of lung tissues (fig. 1). Asthma is characterized by episodes of reversible narrowing of the airways. The episodes can vary from mild chest tightness, shortness of breath, and coughing or wheezing, to a lifethreatening inability to breathe (NHLBI 2002). Asthma occurs in people who are predisposed to develop the disease due to genetic and environmental factors. A wide variety of triggers may start or worsen an asthma attack, including exposure to allergens, viral respiratory infections, airway irritants such as tobacco smoke and environmental pollutants, and exercise.

In addition, diet can have a significant effect on asthma. Asthma is characterized by an oxidant-antioxidant imbalance, and dietary intervention may shift this imbalance by preventing the formation of free radicals, making oxidants less toxic and modulating the immune response in the lung (Hartert and Peebles 2001). Any molecule can become



a free radical by either losing or gaining an electron in normal reactions that occur in the body. Molecules containing these uncoupled electrons are very reactive as they try to capture or donate electrons. The body's defense systems produce antioxidants that neutralize free radicals and protect cells from damage. Antioxidants are also contributed by the diet; there are more than 4,000 compounds that act as antioxidants in foods, including vitamins C, E and magnesium. The relative importance of individual nutrients in asthma control is unclear, but magnesium may be significant (Mathew and Altura 1991).

Treating asthma with magnesium

Current therapies for asthma have limitations. First, there is no known cure; even with treatment, chronic symptoms remain a problem. Common medications for asthma include inhaled corticosteroids, and inhaled or oral beta 2-agonists. Beta-agonists are medications that relax the muscles around airways that tighten during an asthma attack, and corticosteroids are drugs that decrease inflammation within the breathing passages. These are used on a regular basis to control chronic symptoms and prevent attacks. However, these medications can be associated with adverse side effects such as cardiac arrhythmia and other cardiovascular disturbances, causing people with asthma to limit the dosage and frequency of medication use (NHLBI 2002).

Magnesium is an essential mineral with several dietary sources that is found in a variety of foods, including whole grains, green leafy vegetables, legumes and nuts. (Water, if it is high in dissolved minerals, can also be a source of magnesium.) The idea that magnesium could be useful for asthma treatment was first published in 1940, as anecdotal reports describing the beneficial effects of intravenous (IV) magnesium sulphate given during acute asthma attacks (Haury 1940). However, more recent studies assessing magnesium therapy in asthma have given conflicting results. Some studies with IV magnesium suggest that it could be helpful in acute asthma treatment (Cheuk et al. 2005), although other studies show no effect (Bernstein et al. 1995). In addition, while inhaled aerosol magnesium-sulphate improved asthma symptoms in a double-randomized, controlled trial (Rolla et al. 1987), magnesium administered in aerosol form had no effect in another similar study (Chande and Skoner 1992).

These studies suggest that IV and inhaled magnesium may improve pulmonary function in acute asthma, but are not useful in patients with more moderate episodes. It is unclear whether magnesium administration has a specific pharmacologic effect or whether it corrects an underlying deficiency. Certain groups of people, including those with asthma, may not be obtaining adequate dietary magnesium and therefore have low magnesium stores (Britton et al.

Dietary magnesium and asthma risk

1994).

Among the dietary variables associated with an increased risk of asthma is the low consumption of vegetables, milk and minerals, including magnesium. Large, population-based epidemiologic studies have found that lower dietary magnesium intakes were associated with impaired lung function, bronchial hyperreactivity and the increased risk of wheezing (Britton et al. 1994).

Numerous studies show a relationship between low magnesium intake and asthma symptoms, and indicate that intakes of magnesium in the general population do not reach recommended levels. Less than half of American adults consumed the Recommended Daily Allowance (RDA) of magnesium, according to the National Health and Nutrition Examination Survey (NHANES) 1999-2000. The average intake of magnesium by women 19 to 50 years of age was only 74% of the RDA. Men of the same age consumed about 94% of the RDA; in general men consume more food, so they get more magnesium overall.

Due to the inflammation associated with asthma, immune cells in lung tis-



Obesity is a risk factor for asthma, as is low intake of magnesium, an essential nutrient. When obese persons with asthma lose weight, their symptoms are reduced.

sues generate inflammatory mediators and cytokines (Barnes 2004) that then circulate throughout the body and may be a source of low-grade systemic inflammation (which can be identified with a blood test). It has been suggested that those inflammatory processes can be moderated by magnesium (Tam et al. 2003). Adults who consumed less than the RDA for magnesium were as much as 75% more likely to have elevated levels of a marker of systemic inflammation (C-reactive protein) than those who consumed at least the RDA (King et al. 2005). Reducing systemic inflammatory response through weight management and dietary intervention could potentially provide a low-cost way to reduce asthma symptoms.

Obesity — a known risk factor for type 2 diabetes, heart disease and some forms of cancer — is also a risk factor for asthma, and the high energy intakes associated with overweight may increase asthma symptoms. Asthma prevalence is increased in obese people (Ford et al. 2004), and when obese asthma patients lose weight, asthma symptoms are also reduced (Shore and Fredberg 2005).

Measuring magnesium and BMI

In order to better understand the role of dietary magnesium in obese asthma sufferers, we compared magnesium status and dietary intake in people with asthma to healthy controls who were matched by weight and gender. Complete study details have been described elsewhere (Kazaks et al. 2006); the design and methods are briefly discussed below.

Participants. Subjects were recruited with flyers and newspaper advertisements from the general public in the Sacramento area. Based on body mass index (BMI), we matched 18 men and 36 women aged 21 to 55 years old with mild-to-moderate asthma, with 17 male and 30 female healthy control subjects. The two groups were similar in ethnic makeup, and the entire group consisted of 8% Asian, 12% black, 70% white, 12% Hispanic and 9% undeclared individuals (the total is greater than 100% since some subjects were classified as more than one ethnicity). Written, informed consent was obtained from all participants, and the UC Davis Institutional Review Board approved the study protocol.

Procedures. At the initial screening visit, all subjects underwent a health interview and physical exam, and height and weight measurements were taken. At the second visit, all subjects were given a methacholine challenge test to determine bronchial hyperresponsiveness and diagnosis of asthma. At the third visit, all subjects were given an IV magnesium-loading test to determine their magnesium status.

On two separate visits, all subjects were asked to recall what they had eaten in the previous 24 hours, to determine their dietary magnesium intake. The interviews were done by a registered dietitian and analyzed using Food Processor software (ESHA Research, Salem, Ore.). Dietary intake was presented both as average daily magnesium and as a percentage of the magnesium RDA goal for age and gender: 400 milligrams per day (mg/day) for men and 310 mg/day for women ages 19 to 30, and 420 mg/day for men and 320 mg/day for women over age 30 (IMFNB 1997).

BMI categories. BMI was calculated as weight divided by height squared (kilograms per meters squared). Normal weight was defined as a BMI less than or equal to 24.9, overweight was a BMI between 25.0 and 29.9, and obese was a BMI greater than 30.0.

Magnesium status. Bone and muscle biopsies provide the most accurate evaluations of magnesium status. But because this is an invasive and uncomfortable procedure, we used the IV magnesium-loading test instead. Our subjects were given a magnesium infusion (0.1 millimoles magnesium per kilogram) and asked to collect urine for the following 24-hour period.

The principle of the IV magnesiumloading test is that individuals with adequate magnesium status will excrete approximately the entire amount of the infused magnesium within 24 hours. In contrast, magnesium-depleted individuals will retain a large amount of the infused magnesium. A diagnosis of magnesium depletion is based on the percentage of magnesium retained 24 hours after the IV infusion. The normal range for IV magnesium load retention is -39% to 3% (Rob et al. 1999).

Statistics. The results were expressed as mean \pm SEM. Data were analyzed

using Student *t*-tests and analysis of variance (ANOVA). Analyses were conducted with Statview Version 5.0.1 (SAS Institute, Cary, N.C.). *P* values \leq 0.05 were considered significant.

Magnesium, BMI and asthma

We found no significant differences in measures of magnesium status or magnesium intake among participants with asthma and their matched controls (table 1). The IV magnesium load retention was within the expected normal range (–39% to 3%). Because average dietary goals differ according to age and gender, average percentage dietary magnesium goal is a more meaningful indicator of required intake than milligrams magnesium per day. Although there was a wide variation in magnesium intake, mean values showed that both the asthma and control subjects consumed less than the RDA and dietary goal for this essential mineral.

Higher BMI, lower magnesium intake. When all subjects were stratified according to BMI, there were highly

TABLE 1. Measures of magnesium status in gender- and BMI-matched control and asthma subjects*			
	Control (n = 47)	Asthma (n = 52)	
Gender (males/females)	17/30	16/36	
Age (years)	37 ± 1 (21–55)	37 ± 1 (21–55)	
BMI (kg/m ²)†	27 ± 1 (18.5–41.7)	28 ± 1 (19.4–41.7)	
IV magnesium load retention (%)	-19 ± 5 (-110-56)	-24 ± 4 (-80-58)	
Avg. diet magnesium (mg)‡	326 ± 15 (173–608)	306 ± 17 (155–716)	
% diet magnesium goal§	94 ± 5 (53–196)	89 ± 5 (49–178)	

* Values expressed as mean ± SEM (range).

† BMI = body mass index.

‡ Avg. diet magnesium = average dietary magnesium intake.

§ % diet magnesium goal = percentage of RDA of magnesium for age and gender.



TABLE 2. Measures of magnesium status in all subjects, categorized by BMI*

	Normal (n = 36)	Overweight (n = 25)	Obese (n = 38)	P†
IV magnesium load retention (%)	-38 ± 5	-17 ± 7	-10 ± 4	< 0.0001
Avg. diet magnesium (mg)‡	362 ± 23	294 ± 16	285 ± 15	0.006
% diet magnesium goal§	104 ± 7	84 ± 5	83 ± 4	0.01

* Mean \pm SEM. BMI = body mass index; normal \leq 24.9; overweight = 25–29.9; obese \geq 30.

† Difference between normal and obese categories.

‡ Avg. diet magnesium = average dietary magnesium intake.

§ % diet magnesium goal = percentage RDA of magnesium for age and gender.



▲ Fig. 2. Percentage dietary goal for magnesium (Mg) intake in control and asthma subjects, by BMI category. Normal BMI ≤ 24.9; overweight = 25–29.9; obese ≥ 30. * Indicates significant difference between overweight and obese, when compared with normal category ($P \le 0.05$).

▶ Fig. 3. Percentage (A) dietary goal for magnesium (Mg) intake and (B) intravenous (IV) Mg retention in control and asthma subjects, by BMI category. Normal BMI ≤ 24.9; overweight = 25–29.9; obese ≥ 30. * Indicates significant difference between control and asthma subjects in the obese category ($P \le 0.05$).

significant differences in magnesium intake and status (table 2). As BMI increased, IV magnesium load retention was higher (P < 0.0001), and average dietary magnesium intake (P = 0.006) and percentage of dietary magnesium goal (P = 0.01) were lower.

Asthma and lower magnesium intake. When BMI categories were further divided into asthma and control groups, the control subjects had no significant differences in magnesium intake according to percentage dietary magnesium goal in any BMI category (fig. 2). However, asthma subjects had significantly lower magnesium intakes when they were overweight (P = 0.004) and obese (P = 0.001) than did normalweight asthma subjects.

Figure 3A shows how percentage dietary magnesium goal varied according to BMI category when the asthma and control subjects were analyzed separately. Two-way ANOVA with



percentage dietary magnesium goal showed an interaction between BMI category and asthma or control status (P = 0.039), with a lower overall percentage magnesium dietary goal associated with asthma. There were no significant differences between the asthma and control subjects in the normal and overweight categories. However, the percentage dietary magnesium goal was significantly lower in obese asthma subjects than in obese controls (P = 0.023).

In both asthma and control participants, the percentage IV retention significantly increased as BMI category increased (P = 0.005) (fig. 3B).

Increasing dietary magnesium

A limitation to our study was the small sample sizes that resulted when the population was stratified. Even so, robust relationships with the BMI categories were evident. Our study also could have been strengthened by deter-



Good sources of magnesium include bran muffins, pumpkin seeds, barley, buckwheat flour, low-fat yogurt, trail mix, halibut steaks, garbanzo beans, lima beans, soybeans and spinach. Increasing dietary magnesium may reduce asthma symptoms while aiding in weight loss.

mining the income status of subjects to define how it relates to dietary magnesium and asthma. (The role of dietary magnesium supplements is the subject of another paper by the authors; in this study, subjects were limited to 50 milligrams or less per day of magnesium in dietary supplements.)

Further study is necessary to determine how people with asthma respond to the combined effects of low magnesium and increased obesity. Does inadequate magnesium intake combined with obesity increase the risk of asthma? Or does low magnesium intake combined with asthma increase obesity?

Nonetheless, this study demonstrates that people with mild-to-moderate asthma and their matched healthy controls had no differences in magnesium status or intake unless they were analyzed within BMI categories. This emphasizes that BMI must be taken into

Asthma subjects had significantly lower magnesium intakes when they were overweight and obese than did normalweight asthma subjects.

account to understand the biologic and behavioral influences on asthma.

Many people with asthma try complementary and alternative therapies in addition to traditional medical treatments. A 1998 survey of health care providers identified various alternative treatments used by people with asthma; dietary and nutritional approaches were the most prevalent options and were believed to be the most useful (Davis et al. 1998).

We suggest that reducing obesity and increasing magnesium-containing foods may have a dual impact on asthma control. Likewise, replacing lowmagnesium foods with high-magnesium foods may help reduce the risk of obesity in people with asthma. For most people, the best way to make sure that they get enough magnesium is to eat a wide variety of whole grains, green leafy vegetables, beans and nuts (table 3). In general, eating a varied diet that includes an abundance of fruits and vegetables also helps to prevent obesity. A combination of weight management and dietary intervention could reduce the systemic inflammatory response characteristic of asthma. Increasing dietary magnesium is a low-cost intervention that also may improve overall health.

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TABLE 3. Selected food sources of magnesium Food, standard serving* Magnesium Calories mq Pumpkin and squash seed kernels, roasted, 1 oz. 151 148 Brazil nuts, 1 oz. 107 186 Bran, ready-to-eat cereal (100%), 1 oz. 103 74 Halibut, cooked, 3 oz. 91 119 Almonds, 1 oz. 78 164 Spinach, cooked from fresh, 1/2 cup 78 20 White beans, canned, 1/2 cup 67 154 Black beans, cooked, 1/2 cup 60 114 Tuna, yellowfin, cooked, 3 oz. 54 118 Peanuts, dry roasted, 1 oz. 50 166 Lima beans, baby, cooked from frozen, 1/2 cup 50 95 Soy beverage, 1 cup 47 127 Oat bran muffin, 1 oz. 45 77

Standard servings are \geq 10% of RDA for adult men (420 mg/day). Source: USDA 2006.

Great northern beans, cooked, 1/2 cup

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UCCE helps community coalitions reduce childhood overweight

by Gloria B. Espinosa-Hall, Diane Metz, Margaret Johns, Dorothy Smith, Patricia B. Crawford, Kirstin Siemering *and* Joanne Ikeda

In 2001, UC Cooperative Extension nutrition specialists with the Center for Weight and Health introduced the **Children and Weight: What Commu**nities Can Do About It project, with the goal of reducing the prevalence of pediatric overweight. This project was designed to facilitate the formation of community coalitions, and to educate and empower them to improve or create environments that foster healthy lifestyles in children and their families at the local level. The project has been implemented in 13 California counties and by groups across the country. The "Spectrum of Prevention" is featured as a way to address the problem of pediatric overweight from multiple levels, ranging from educating individuals and providers to advocating for systemic and environmental change. Shasta CAN in Shasta County, the Solano County Children and Weight Coalition and the Kern County Childhood Overweight Coalition are presented as models of how coalitions can creatively plan and implement activities across the spectrum.

IN the late 1990s, UC Cooperative Extension nutrition specialists and Experiment Station faculty began to notice a dramatic increase in overweight children in California. Pediatric overweight had become "epidemic": its prevalence had tripled from 5% to 15% over the preceding 30 years and rates were significantly higher for minority children, especially those from low-income families (fig. 1) (Troiano and Flegal 1998). Overweight children



Children have been gaining weight in recent decades due to factors such as the school environment, community design and safety concerns that discourage outdoor play, and diets increasingly heavy in sugar and fat.

as young as 6 years old were receiving diagnoses of hypertension, hyperlipidemia (high serum cholesterol or high blood triglycerides) and joint problems. In addition, the risk of chronic disease later in life was increased for these children. California children born in 2000 had an estimated one in three chance of developing type 2 diabetes during their lifetimes (Fagot-Campagna et al. 2000).

Specialists and faculty realized that one of the major factors contributing to this environment was a rapidly changing environment. Schools in California were selling foods of poor nutritional quality to children to raise funds for school programs, activities and events. Daily physical education was reduced or eliminated, since it was viewed as less important than classroom instruction (AAHPERD 2005). With the new emphasis on test scores, there was little incentive to teach children how to care for their physical, social and emotional health. In addition, fewer children were walking and bicycling to school (CDC 2006).

Outside of school, children's environments had also changed. Many communities lacked sidewalks, but even in places with sidewalks, parents worried about safety issues related to children walking or riding alone. Too many urban parks had become places where the homeless resided or where drugs were sold. Low-income neighborhoods lacked supermarkets that stocked a variety of reasonably priced fresh produce, but had many liquor stores and fast-food restaurants. Few children were spending even 1 hour playing actively, and the average child spent over 4 hours a day in front of the TV screen (Roberts and Foehr 2004). Television commercials emphasized the desirability of soft drinks, sugar-coated cereals and eating at fast-food restaurants. The advertising industry was effective at marketing high-sugar and high-fat foods to children: by the late 1990s, nearly a third of the calorie intake of the average child in this country came from foods of poor nutrient density (Kant 2003).

The number of children and families affected by these societal, cultural and familial changes was so great that it was felt that an individual education approach (one-on-one counseling for each person or family at risk) would overwhelm the capacity of our health education system. Recognizing that no one group, agency or organization was going to be able to reverse the environmental trends underlying the rise in overweight children, UC nutrition specialists and faculty agreed that the only way to deal with the problem of pediatric overweight was through a community organizing approach that focused on environmental change. The formalization of such "bottom-up" community involvement in addressing health problems has been driven by past failings of "top-down" approaches (Zakocs and Edwards 2006).

Forming community coalitions

The development of community coalitions has become a defining approach to addressing social problems over the last decade (Chavis 2001). A coalition or alliance is formed when a group of individuals or organizations decides to work together to achieve mutually agreed-upon goals. Community coalitions bring together partners with diverse interests but the common goal of wanting to address a problem that is having a detrimental impact on community members. Each partner contributes resources that mobilize and focus on resolving the problem. These alliances have great potential for transforming communities because they can engage different segments of the community to develop the capacity to achieve a healthier environment.

The "Children and Weight: What Communities Can Do About It" project began with a series of meetings conducted by county UC Cooperative Extension nutrition, family and consumer science advisors. After launching the project in a statewide meeting held Nov. 17, 1999, local Cooperative Extension staff returned to their communities to conduct focus groups. The purpose of these groups was to assess community needs and perceptions of the problem of increasing pediatric overweight, and to begin to build local coalitions for future action. Eight focus groups were held in urban, suburban and rural communities in Northern and Southern California, and the Central Valley. The advisors asked

representatives of various community agencies and institutions to brainstorm about how their community environment might be contributing to pediatric overweight and the changes that they would like to accomplish. Since this was a newly publicized health problem, there was a great deal of interest, and about 100 people attended the meetings.

Although enthusiasm for change was high, many individuals were pessimistic about the possibility of actually making a difference. In most cases, participants felt overextended and worried about the time and energy it would take. Since many were entrenched in the bureaucratic structures of their organizations, they did not feel they had the power and influence to effect change. However, when the possibility of forming an alliance that would include key community decision-makers and leaders was suggested, the participants were more enthusiastic.

Although there were numerous commonalities — such as the need to promote physical activity and provide consistent, accurate health information — these meetings suggested that there was no universal item among communities that they wanted to change. Each community identified its own unique set of problems as well as potential changes that its members felt were important. However, we identified a need to help communities prioritize and develop action plans to accomplish their goals. There was also a need to educate coalition members about the issues surrounding pediatric overweight so their efforts would focus on effective changes to address this problem.

Resources for starting coalitions

Based on these meetings, specialists and advisors determined that resources were needed to facilitate the formation. education and functioning of community coalitions. While the overall goal was to reduce the prevalence of childhood overweight in California, this tool was also designed to mobilize communities to create opportunities for children to eat nutrient-dense food such as fruits, vegetables and whole grains, and to become more physically active. These resources were developed and packaged as Children and Weight: What *Communities Can Do,* a kit that included: (1) a "how to" notebook with advice on forming a coalition; (2) templates for notices and agendas for meetings; (3) educational presentations on various aspects of pediatric overweight to be used at meetings; and (4) a decisionmaking process to implement over the course of five meetings. In addition, specialists made a videotape featuring coalitions in California that had accomplished environmental changes in community settings.

The resource materials were based



Fig. 1. Prevalence of overweight among U.S. children and adolescents ages 6–19 years (excludes pregnant women starting with 1971–1974 data). Overweight is a BMI greater than or equal to the 95th percentile for the child's age and sex. Source: NCHS 2007.

on a framework for addressing complex public-health problems called the "Spectrum of Prevention" (Cohen and Smith 1999). Originally developed by Larry Cohen when he was director of the Contra Costa County Health Services Prevention Program, the Spectrum of Prevention identifies multiple levels of intervention, and encourages coalitions to move beyond the perception that preventing a health problem is solely about teaching individuals to adopt healthier behaviors. Instead, this approach is designed to yield a more comprehensive understanding of prevention via six strategy development levels, extending from the individual to the government (fig. 2) (Cohen and Smith 1999).

Children and Weight coalitions

Between 2001 and 2005, county Cooperative Extension nutrition, family and consumer science advisors facilitated the formation of Children and Weight coalitions in 13 California communities (table 1). A 2004 survey of members of these coalitions found that they used multilevel strategies to create environments that support healthier lifestyles for children and their parents, including:

(1) Promoting community education and awareness using local newspapers, radio and television stations.

(2) Providing continuing medical education on all aspects of pediatric overweight for health professionals.

(3) Identifying treatment and intervention programs available in the community and supporting the expansion of these services.

(4) Sponsoring events for children and parents that promote the enjoyment of eating nutrient-dense foods and being physically active.

(5) Advocating for changes in the food sold in school vending machines and snack bars.

(6) Emphasizing the link between health and academic achievement so that schools recognize the importance of physical education and comprehensive school-health programs.

(7) Improving the safety of and access to community recreation facilities

Spectrum of Prevention

knowledge and skins	vidual capacity
Promoting community education Reach grou	ups with n and resources
Educating providers	ders who ters
Fostering coalitions Convene g individuals	roups and for greater impact
Changing Adapt regula organizational practices shape norms	itions and
Influencing policy and legislation Change law	rategies to vs and policies

Fig. 2. Source: Cohen and Smith 1999; www.preventioninstitute.org.

as well as the expansion of recreational opportunities for families.

(8) Encouraging children to walk or ride their bikes to school through the establishment of "walking school buses" and parent "corner" monitors along routes to schools.

The following three case studies from the 13 coalitions demonstrate the unique and varied approaches taken by community coalitions to reduce the prevalence of pediatric overweight in California.

Shasta CAN

The Shasta County Coalition for Activity and Nutrition (Shasta CAN) was started in 1999 by a group of local dietitians who were alarmed about the epidemic of childhood overweight. In summer 2001, the group's leader and the county's newly hired UC Cooperative Extension nutrition advisor attended a training hosted by the UC Berkeley Center for Weight and Health training on the Children and Weight program.

Their immediate goal following the training was to expand the coali-

tion by recruiting additional partners from local agencies. Members visited schools to educate teachers and administrators about the increasing prevalence of childhood overweight and its consequences. The group sponsored a Children and Weight Conference, featuring Shasta County's health officer and a UC Berkeley nutrition specialist. To serve as the basis for Shasta CAN's strategic plan, conference attendees selected three goals they would like to see accomplished in their community.

Shasta CAN served as a countywide venue for planning, coordinating, delivering and evaluating nutrition and physical activity efforts. By pooling resources, coalition members reached larger audiences with programs that have greater impact on lifestyle behaviors.

In Shasta County, entire schools have participated in "Nutrition Decathlon" events, where children answer nutrition trivia questions in exchange for tickets to participate in physical activities that involve a fruit or a vegetable, such as the carrot hop, coconut bowling and potato-sack races. Thousands of students use pedometers to track the number of

TABLE 1. California Children and Weight community coalitions

steps they take in a day. Many more take the "Nutrition and Physical Activity Challenge" by eating at least 5 cups of fruits and vegetables and being physically active for at least 1 hour each day.

Shasta CAN's community education efforts have focused primarily on "Lean-N-Green Day," held annually in March (National Nutrition Month), and the "5-A-Day Challenge" held annually in September. Thousands of residents are exposed to nutrition and physical activity messages through mass media campaigns, fairs and coalition-sponsored community walks. After Lean-N-Green Day in 2005, 72% of participants surveyed by the coalition reported that the event influenced their level of commitment to physical activity and their intake of fruits and vegetables.

Coalition members have educated teachers, food-service staff, health professionals, school board members, and members of the city council and county board of supervisors on their role in promoting and supporting a healthy environment for children and families. Even before the Federal Child Nutrition and WIC Reauthorization Act of 2004 made it mandatory for every school district to create a local wellness policy (CBO 2004), several Shasta County schools had started making changes in order to create a healthier school environment. Some schools started offering low-sugar, low-fat snacks, while others limited the frequency of selling sweets for fundraisers or started offering healthier food choices during sporting events. Some schools developed policies banning the sale of soft drinks and other highly sugared beverages. One school district adopted a policy that healthy foods and beverages should be available wherever food is offered or sold within the district. As a result of coalition members' involvement in the promotion and education of healthy school environments, several members have been invited to help form local wellness-policy committees.

In addition, some agencies in Shasta County have initiated organizational changes that contribute to improved employee health, such as offering

County (no. members)		.
Amador/Calaveras (21) Dorothy Smith Dorseith@urdavis.adu	Connect community resources into a common basket	Hunger survey Cross County Health Challenge
Contra Costa (20) Charlotte Dickson cdickson@hsd.cccounty.us (925) 313-6217	Advocate and promote healthy lifestyles and environments that improve nutrition and physical activity for children and families	 Video for families on physical activity Treatment guidelines for providers School nutrition modules Social marketing campaigns
Kern (15) Margaret Johns MCJohns@ucdavis.edu	Improve the health of children and their families through the prevention of weight problems and related chronic diseases	 Community information presentations Professional development programs for physicians and health professionals
Marin (20) Jane Chin Young JChin@ucdavis.edu	Improve the health of Marin County in the next decade	 Healthy snack activities at high schools Middle school students as leaders Nutrition and Health Educational Theatre
San Diego (58) Beverly Tuzin contact@ccwsd.org (619) 692-8808	Prevent childhood overweight by addressing its complex contributing factors	 School food and fitness summits Conference for health professionals Toolkit for School Board Advocacy and Practice Management
San Joaquin (25) Anna Martin ACMartin@ucdavis.edu	Promote environmental and policy changes that facilitate healthy lifestyles for San Joaquin County children and their families	 National Walk-to-School Day "Active for Life" workplace program Collaborate to reduce hunger and food insecurity
Santa Barbara (25) Christy Schuerch Christy@sbclinics.com (805) 963-8566 x221	Improve the health of youth and their families; prevent chronic disease and promote healthy weight	 Portion-size education Expand healthy food choices in youth environments Increase physical activity among youth
Santa Clara (50) Maria Giovanni MEGiovanni@ucdavis.edu	Improve the health of children and their families through strategies that address weight problems and chronic diseases	 Child-feeding trainings School nutrition and physical activity Policy changes Treatment program for overweight children
Shasta (25) Sherrie Brookes sbrookes@co.shasta.ca.us	Empower the people of Shasta County to make positive food choices and to be more physically active	 School nutrition and physical activity Treatment program for overweight children Professional development conferences Pedometer program
Solano (70) Diane L. Metz DLMetz@ucdavis.edu	Improve the health and well-being of children and their families by creating an environment that promotes healthy lifestyles	 Forums for countywide strategic plan Walk or bike to school event Healthy Eating Active Living (HEAL) initiative (Kaiser grant); workshops for various groups
Sonoma (32) Wanda Tapia WCTapia@ucdavis.edu	Improve the health of children and their families through the prevention of chronic disease and weight problems	 Seminar on body image Community resources for families School food policy Farm to school
Trinity (10) Eileen Stocum estocum@trinitycounty.org	Improve the health of children and families through the education and promotion of good nutrition and physical activity	 School nutrition and physical activity education School food-service trainings Annual Children's Festival TV Turnoff Week
Yolo (25) Maryfrances E. Collins Maryfrances.Collins @yolocounty.org (320) 666-8662	Create environments that enhance nutritional and physical activity in Yolo County	• Develop strategic plan

UC Cooperative Extension nutrition specialists developed a training kit with a variety of materials for helping communities form coalitions. To order, go to: http://anrcatalog. ucdavis.edu.

nutrient-dense refreshments like yogurt, fruit and nuts at staff meetings. Luncheon meetings have a greater variety of vegetables and lower fat dishes, and sodas have been replaced by water and 100% fruit juice. Employees are encouraged to participate in walking groups during breaks and lunchtime.

Another important development in Shasta County is the formation of a coalition called Healthy Shasta, which has the primary goal of working at a higher level of the Spectrum of Prevention. This coalition has enlisted the support of county officials, CEOs and department heads, to concentrate in seeking funds and developing countywide policies and environmental changes that support the establishment and sustainability of a healthy community.

Solano County coalition

In 2001, several Solano County Health Department professionals formed a group to promote lifestyle changes that would encourage healthy weights for children. Following training at the UC Berkeley Center for Weight and Health, the UC Cooperative Extension nutrition, family and consumer science advisor joined the planning team from the Solano County-based coalition. The group agreed to pilot-test the Children and Weight: What Communities Can Do curriculum that had been introduced at the U.C. Center for Weight and Health trainings. In November 2001, 40 people attended the first meeting of the Children and Weight Coalition of Solano County (CWCSC). This coalition met monthly during its first year, working its way through the coalitionbuilding curriculum, recruiting members and making suggested changes to the curriculum.

In October 2002, CWCSC sponsored a countywide forum attended by more than 50 individuals, including representatives of county and city agencies, health departments and schools from



each of the county's six cities. Funds were secured through The California Endowment and local organizations, which enabled the coalition to convene community-based forums in Benicia, Dixon, Fairfield-Suisun, Rio Vista, Vacaville and Vallejo, as well as one for educators and another for health professionals. By December 2003, more than 400 people had attended these eight forums. The data gathered was tabulated and used to create the coalition's strategic plan. The project funds also allowed the group to test and design appropriate social marketing tools and develop the coalition's Web site (www.cwcsc. com). In 2004, CWCSC finalized its strategic plan, published and distributed it throughout the county, and presented it to the board of supervisors, where it was adopted.

Based on the plan, the group formed teams to coordinate events such as "Walk to School Day," which was offered in five of the six Solano County cities in fall 2004. Kaiser Permanente and North Bay Health Care provided funds for healthful food and activity incentives such as water bottles and wristband whistles to encourage more physical activity.

In late 2004, CWCSC received funds from Kaiser Permanente's Healthy Eating Active Living (HEAL) initiative. At a planning retreat in March 2005, members decided that these funds would be used to carry out communitybased projects promoting childhood health. Community teams were encouraged to apply for mini-grants of \$1,000, and four projects were funded:

(1) In Benicia, Robert Semple Elementary School purchased Sports, Play and Active Recreation for Kids (SPARK) equipment to promote physical activity.

(2) In Dixon, Silveyville Primary School conducted education classes on gardening, nutrition and physical activity for new immigrant parents.

(3) Child Start of Napa-Solano trained 46 Head Start teachers to use the SPARK curriculum when doing physical activity with preschoolers.

(4) Vallejo City Unified School District Student Health Services supported Walk to School activities reaching more than 350 children and adults.

Another CWCSC project using HEAL funds provided nutrition education to 20 parent-child teams in Fairfield, where lifestyle and health promotion information was shared, and participants prepared healthful meals and snacks. In addition, CWCSC used HEAL funds to offer Smart Moves workshops in Fairfield and Vallejo targeting day-care and after-school child-care providers. These workshops provide instruction on easy ways to



By pooling resources, coalition members have the opportunity to reach a much larger audience with programs that have greater impact on lifestyle behaviors.

Throughout California, community coalitions have been formed to develop comprehensive approaches for combating childhood overweight. The Shasta County Coalition for Activity and Nutrition (Shasta CAN) hosts an annual Lean-N-Green Day to promote health and fitness, during which kids played a "My Pyramid" nutrition education game.

incorporate movement and increase the physical activity for children. More than 65 child-care providers attended the first round of workshops held in November 2005, and two more workshops were held in Vacaville and Vallejo in March 2006 to accommodate 35 providers on the waiting list.

Most cities in Solano County continue to carry out annual Walk to School events. Cooking classes for parents are offered in Dixon, soda machines at schools throughout Solano County now offer water and lowersugar beverages, and several school districts now offer more nutritious foods and portions in their cafeterias.

CWCSC has also worked to promote local agriculture. Solano County's population has more than doubled in the past 20 years, now exceeding 425,000 residents, mostly in urban areas. With such growth, many residents do not realize that agriculture remains one of the county's largest industries. The Food and Nutrition Coalition, an offshoot of CWCSC, has developed companion activities with support from the food banks of Contra Costa and Solano counties, and the Solano County Department of Health and Social Services. Both coalitions promote eating local produce and foods (such as whole grains and beans) by working with grower associations and farmers' markets.

CWCSC distributes "Solano Grown" flyers to promote the purchase of locally grown foods directly from farmer food stands in the county. The coalition has also found that using locally grown food in demonstrations and cooking activities piques the interest of participants. Increasingly, consumers want to know where their food is grown and how fresh it is; meanwhile, working with growers enables the agricultural community to see more clearly the connection between health and the products they produce and sell.

CWCSC's focus is to provide support for Solano County communities to take action based on local needs. Coalition members further extend their impact by providing information sessions to a broad array of agencies, organizations and individuals throughout the county. CWCSC helped Napa County to start its own Children and Weight coalition. CWCSC members have provided training sessions for South Carolina and Ohio Cooperative Extension advisors, served as consultants for similar coalitions across the nation and in Canada. and extended information about the CWCSC at regional sessions and three national health-promotion conferences.

Get Moving Kern

Kern County's first Childhood Overweight Coalition meeting was held in Bakersfield in February 2002. Invitations announcing the first two meetings were mailed to 600 Kern County individuals, agencies, schools, health insurance companies, community health organizations, the agriculture community and other organizations. These initial meetings were attended by 30 to 40 people. From February 2002 to October 2004, the meetings were co-chaired by the county's UC Cooperative Extension nutrition, family and consumer advisor and a health educator from the Kern County Department of Public Health.

The Children and Weight: What Communities Can Do curriculum was used to guide the first four meetings. A "Community Food and Fun Day" was the first project the group pursued, but lack of support by members of the coalition to plan the event doomed it to failure. In a festival-type setting, it was planned to have people participate in cooking demonstrations; taste healthy, reduced-fat foods; and try out low-cost, family-centered physical activities. The coalition regrouped and sponsored three community information meetings and workshops for the public, physicians and health professionals.

During this time, the city of Bakersfield was in the midst of a strategic planning process (called Bakersfield Visions 2020) that included a task force on obesity. The Childhood Overweight Coalition merged with this task force in January 2005 to form "Get Moving Kern." This new coalition includes about 15 members, primarily from healthrelated fields, and meets monthly. Get Moving Kern focuses on increasing physical activity and spreading the message of consuming more fruits and vegetables. They have developed a logo, launched a Web site and are currently looking for grant opportunities.

UC Cooperative Extension in Kern County continues to be a member of the obesity coalition, and new stakeholders have joined, including the physical education department of California State University, Bakersfield. Unfortunately, the local farming community did not respond to the Childhood Overweight Coalition's invitation to participate in the coalition meetings; they are an important missing link in the planning process. Kern County is one of the largest fruit- and vegetable-producing counties in the United States, and farmers are an important source for the donations of fresh fruits and vegetables for public events, which have been successfully used to reach the public with healthy-eating messages.

Get Moving Kern and other childhood obesity coalitions need to do more aggressive outreach and education to attract missing stakeholders such as farmers, community members, schools, restaurants, and individuals and companies involved in sports and physical activity. These groups would bring a different perspective to the planning process.

Team approaches to health issues

As these case studies demonstrate, the community coalition approach harnesses resources that are already available by drawing upon a diversity of community partners, their expertise and



Community coalitions harness resources by drawing upon diverse partners and applying resources strategically. In Shasta County, Redding Mayor Dick Dickerson (second from left) and Anderson Mayor Keith Webster (third from right) are collaborating to promote better nutrition and physical activity countywide.

scopes of influence. These ingredients maximize the coalition's effectiveness and enhance the possibility of achieving its mission. The community coalitions we have worked with have increased awareness of childhood overweight as a potential health issue and improved the well-being of children and youth in these locales. The future holds great promise for coalitions to assist with this epidemic and encourage others to consider developing coalitions as a tool.

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Local diffusion networks act as pathways to sustainable agriculture in the Sacramento River Valley

by Mark Lubell and Allan Fulton

Greater sustainability is one of the main goals of agricultural and natural resource policy in California and worldwide. "Diffusion networks," which consist mainly of connections among producers, local outreach and education agencies and agricultural organizations, provide critical pathways for achieving sustainability. We analyzed the role of diffusion networks in the context of agricultural water-quality management in the Sacramento River Valley. Data from a survey of more than 1,200 agricultural producers demonstrates the role of diffusion networks in increasing satisfaction with environmental policies, participation in water-quality management programs and the implementation of sustainable agricultural practices.

Greater sustainability has become one of the primary goals of agricultural and natural resource policy in California and worldwide. Although there is certainly no consensus on the meaning of sustainability, most definitions include three principles: environmental health, economic viability and social equity (Brown et al. 1987; Schaller 1993).

Agricultural water-quality management is an excellent case study because it involves all three principles of sustainability. The goal is to reduce the potential negative environmental impacts of agricultural production while maintaining economic viability and considering the diversity of agricultural communities. Non-point-source pollution in storm-water runoff and irrigation return flows is the cumulative result of individual decisions made by all producers in a watershed. Therefore, reducing the environmental impacts of agriculture illustrates what we believe is a central challenge in sustainability:



Formal and informal connections, called "diffusion networks," encourage growers in the Sacramento River Valley to implement new practices that improve water quality. At a field day in Chico, Allan Fulton shares information on the different methods available for managing tailwater runoff from irrigated fields.

understanding attitude change and encouraging cooperation among large numbers of individual resource users. This same challenge is seen in other sustainability issues, such as urban water conservation and global warming, where solutions will require large-scale collective action.

Local diffusion networks

We focus on the environmental aspect of sustainability, in the context of agricultural water-quality management in California's Sacramento River Valley. Our central thesis is that local "diffusion networks" — involving producers, local public agricultural agencies and private agricultural organizations — offer three potential pathways for achieving sustainability. These networks (1) provide information about innovations in agricultural practices, (2) act as a repository of social capital for solving collective dilemmas and (3) facilitate cultural change.

Information communication. Classic diffusion networks are defined as members of a social system that communicate information about agricultural practices and issues through formal and informal connections and interactions (Rogers 2003). Diffusion networks enable adoption decisions by spreading awareness about the costs and benefits of innovations. Recent studies focus on how the different structural characteristics of diffusion networks affect the rate and pattern of information flow (Conley and Udry 2001; Chiffoleau 2005). Diffusion processes were an important aspect of the post-World War II "Green Revolution," which featured the widespread, international adoption of new technologies to increase agricultural productivity (Evenson and Gollin 2003).

In the United States, diffusion networks have been evolving since the late 19th century in the form of local special districts, commodity organizations and



In a survey of Sacramento River Valley growers, nine different network contacts were needed for the addition of one best management practice (BMP) for water quality. Some BMPs used by producers included: *left*, a new lower-volume, targeted blast, orchard-sprayer (shown being demonstrated with water only); *center*, resident orchard vegetation to improve infiltration and reduce runoff; *right*, pheromone puffers hung in trees to manage insect pests.

government-supported education and outreach programs. Among the earliest examples are land-grant universities and their associated networks of county Cooperative Extension offices, which help deliver scientific research and knowledge to agricultural stakeholders. The Smith-Lever Act of 1914 established Cooperative Extension, roughly in conjunction with the California Farm Bureau Federation (Scheuring 1995).

Some agricultural practices contributing to the Green Revolution — such as pesticide use for improved crop protection, fertilizer applications for enhanced plant nutrition, and irrigation for more reliable crop performance — are now considered partial contributors to agricultural non-point-source pollution. To effectively address agricultural impacts on the environment and still maintain economically viable operations, greater sustainability will entail the adoption of more environmentally friendly, yet agronomically sound, best management practices (BMPs). Diffusion networks are playing a key role in delivering information about environmental issues and BMPs in an era when sustainability is increasingly emphasized.

Social capital. Diffusion networks are also an investment in *social capital,* which consists of interconnections within a community, norms of reciprocity and social trust (Ostrom 1994; Putnam 2000). Social capital is a critical resource for solving collective-action problems in which the costs and benefits of agricultural practices are influenced by the decisions of numerous producers. For example, one producer's water-quality management efforts will achieve only an incremental reduction in non-pointsource pollution. However, if producers who share a common interest in a watershed work cooperatively to implement BMPs, the collective benefits to water quality will be greater. These collectiveaction problems are further complicated when some producers decline adoption and may be perceived to benefit (as "free riders") from the participation of others. Diffusion networks help agricultural stakeholders overcome these collective dilemmas to the extent that they serve as reservoirs of social capital and trust.

Cultural change. Finally, diffusion networks can also be pathways for cultural change and, more broadly, cultural evolution (Henrich 2001; Richerson and Boyd 2005). Theories of cultural evolution hypothesize that social learning from other people is a key mechanism of cultural change. Social learning occurs when one member of the social system makes decisions on the basis of the behavior of his or her peers. For example, some producers may observe and then follow the practices of the most successful operations in their community. Social learning may also involve processes of persuasion, where people in the group who have specific expertise in BMP development and water-quality management may actually change the preferences of other individuals. Importantly, diffusion networks provide information not only about a particular innovation, but also about the expertise and socioeconomic characteristics of other actors in the network.

Viewing diffusion networks as pathways to cultural change is particularly important in the case of water-quality management, where mitigating any identifiable non-point-source pollution depends on changes in the behaviors, attitudes and beliefs of the relevant agricultural community. Part of this change involves various government policies that reward preferred actions or penalize behavior that is defined as "unsustainable." But significant cultural change is more likely to occur when accompanied by the acceptance of new behaviors and norms throughout a community. Theories of cultural evolution emphasize the role of social learning and diffusion networks in gaining the acceptance of principles and policies of sustainability in agriculture (Richerson and Boyd 2005).

This article provides empirical evidence for the important role of diffusion networks in sustainable agriculture by describing how local agencies have facilitated participation in water-quality management. We focus specifically on the Sacramento Valley Water Quality Coalition (SVWQC), which emerged in response to new regulatory requirements passed by the Central Valley Regional Water Quality Control Board (Region 5 board). Using data from a survey of over 1,200 Sacramento River Valley producers, we show how diffusion networks have increased satisfaction with coalition policies, participation in coalition activities and the implementation of environmental BMPs.

Sacramento River Valley study

The Sacramento River Valley supports about 2,145,000 acres of irrigated land across 250 different drainage areas. About 85% of the irrigated land is on the valley floor and about 15% is in nearby foothills and mountain valleys; about 65,100 acres are seasonal and permanent wetlands. More than 60 different crops are grown in the valley, primarily rice, orchards and irrigated pasture. Agricultural water-quality constituents of concern include pesticides, pathogens, sediment and nutrients, and physical pa-



By joining a watershed management coalition, growers can work jointly to reduce non-pointsource pollution while meeting requirements of the Central Valley Regional Water Quality Control Board's "Conditional Waiver" program. A sample crew monitors water quality in a Tehama County waterway in accordance with the Conditional Waiver.

Diffusion networks support three pathways that are essential to sustainability: information about innovations, social capital and cultural change.

rameters such as temperature, dissolved oxygen and dissolved organic carbon. A total maximum daily load (TMDL) is in effect for diazinon insecticide on the Feather River from below Oroville Dam to the confluence of the Sacramento River. Additional TMDLs are being developed in the Delta and other Central Valley watersheds, targeting both urban and agricultural pollutants. Recent agricultural water-quality monitoring (under the Conditional Waiver, see below) has indicated relatively good surface water quality throughout the Sacramento River Valley with isolated areas of concern that may also be influenced by nonagricultural land uses.

Agricultural water-quality management has recently become a controversial topic in the Central Valley because of the so-called Conditional Waiver program, first adopted by the Region 5 (Central Valley) board on Jan. 1, 2003, and recently revised and extended into 2011 (CVRWQCB 2007). The waiver regulates non-point-source pollution by requiring irrigated agricultural producers to choose one of three options: (1) join a watershed management coalition, an organized group of producers who work together to conduct waterquality monitoring and implement best management practices when problems associated with irrigated agriculture are found; (2) as an individual, request (from the Regional Board) coverage under the Conditional Waiver apart from a coalition; or (3) as an individual, submit a Request for Waste Discharge

Requirements from the Regional Board and then operate under a permit.

The majority of producers in the Sacramento River Valley have opted to join the SVWOC, the area's most encompassing watershed-management coalition, because it allows them to share the costs of the monitoring program, facilitates local oversight, takes advantage of local knowledge and is less intrusive on individuals. Such coalitions also focus on the watershed, attempt to consider the cumulative effects from multiple operations and try to integrate some of the elements of collaborative policy at the local level (Sabatier et al. 2005). However, some producers in the Sacramento River Valley have criticized the nonvoluntary nature of the program as an unnecessary regulatory burden.

The critical role of diffusion networks is illustrated by the SVWQC's nested watershed approach, which divides the larger watershed into 10 subwatershed groups, based on county and hydrological boundaries (fig. 1). The subwatershed groups are typically headquartered locally with organizations such as the county agricultural commissioner, the county farm bureau or a previously established watershed group. The subwatershed leadership collaborates with other local stakeholders, such as resource conservation districts, UC Cooperative Extension and the federal Natural Resource Conservation Service. The exact structure of the partnerships is different in each subwatershed, reflecting the unique configuration of



Fig. 1. Sacramento Valley Water Quality Coalition (SVWQC) subwatershed map. Source: Northern California Water Association/Ducks Unlimited.

networks, political interests, policy expertise, leadership and individual personalities in each area.

Regional coordination among the subwatershed groups is achieved by three main organizations: the Northern California Water Association (NCWA), Ducks Unlimited (DU) and the Coalition for Urban Rural Environmental Stewardship (CURES). These organizations ensure professional oversight of the water-quality monitoring program, and the timely preparation of required documents and reporting of water-quality monitoring results. The regional coordinators are headquartered in the Sacramento area and serve as a liaison between the Regional Board and producers in the more distant, rural areas of the Sacramento River Valley.

These networks of subwatershed and regional actors represent each of the three pathways for sustainable agriculture. They inform producers about the requirements of the program, opportunities for participation, and appropriate management practices for protecting and enhancing water quality. They are a main source of social capital and trust, and they help build interagency cooperation as well as encourage producer participation. They encourage cultural change by demonstrating the success of various water-quality programs and practices, as well as providing public awareness about individual producers who are outstanding examples of stewardship. Whether the Conditional

TABLE 1: Sacramento River Valley farmers' use of water-quality management practices, 2004

	Farmers
	using
Practices	practice
	%
Conventional pest management	
Base spray timing on weather/wind	88.48
Dispose of rinsate by mixing with water and reapplying to orchard	80.88
Calibrate pesticide sprayers before every application or more than once per year	61.52
Maintain setback/buffer zones when spraying	46.32
Check droplet/nozzle size on sprayer	39.46
Apply dormant sprays to treat problem instead of as a preventive method*	10.78
Alternative pest management	
Provide beneficial insect habitat	30.88
Use pheromone mating disruption	17.65
Release beneficial insects in past 5 years	10.78
Runoff control	
Plant filter strip between orchard and waterway*	50.25
Use resident/planted vegetation as cover crop	36.52
* Percentages are based on two separate subsets of growers: those who indicated using dormant spra year (49% of sample) and those who indicated the their storm-water runoff drains into a waterway of ditch (56%). Growers who did not use dormant sp year (51%) or who said they have no runoff into y (44%) who and repetted to approve guerge to the set of the second set of the set of t	orchard ys every at some of or drainage rays every vaterways

(44%) were not prompted to answer questions about dormant-spray strategies or filter strips. To avoid deleting these observations in table 3, we coded those respondents who skipped the questions as not having the practice.



Fig. 2. Trust and contact with water-quality management organizations.

Waiver program is viewed as collaborative or regulatory policy, the diffusion networks involved with the SVWQC make a positive contribution to sustainability to the extent that they facilitate producer participation in water-quality management.

Survey methods and respondents

To examine the role of diffusion networks, we conducted a mail survey of 5,073 producers from nine Sacramento River Valley counties: Butte, Colusa, Glenn, Shasta, Solano, Sutter, Tehama, Yolo and Yuba. The sample list was constructed mainly from agricultural commissioner pesticide-permit lists. The standard Dillman (2000) methodology of delivery (introductory letter, survey package, reminder, second survey package, second reminder) was used to encourage response. The respondents were divided into a group of known orchard producers and a group of other producers for whom the specific commodities were not known beforehand (the nonspecific group). A 12-page survey was mailed to growers, which included 68 questions about their views on waterquality management, political values and farm characteristics; most of the

> responses were yes/no or 7-point Likert scales. The orchard respondents received several additional questions about orchard management practices.

The survey was administered from November 2004 to February 2005, about 2 years after the introduction of the waiver program. A total of 1,229 producers responded to the survey (24%) response rate), including 408 (32%) from the orchard group and 821 (22%) from the nonspecific group. Except for the analyses of orchard practices (tables 1 and 3), the results presented here apply to the combined 1,229 respondents.

The survey population adequately reflected the diversity of land tenure, operation size, commodity types and operator characteristics (as measured by the USDA National Agricultural Statistic Service's [NASS] Agricultural Census) in the nine counties. To further validate our survey, we conducted follow-up telephone interviews of mail survey nonrespondents in seven of the nine original counties, which targeted 1,078 nonrespondents for whom telephone numbers could be found. Of these, 44.7% were determined as owners of irrigated land and thus eligible for the survey, 16.2% were considered ineligible (mostly out of business) and 39.1% could never be reached.

A total of 300 nonrespondents were interviewed by telephone, and the results suggest that the mail survey respondents were more likely to own instead of lease their land and to have slightly higher rates of participation in the coalition groups. This means that we do not have a complete picture of the least-engaged producers, and reflects the difficulty of communicating with smaller and part-time producers. However, the survey does sufficiently represent the economically and politically significant segment of producers who will have the most influence on policy decisions and eventually, the behavior and attitudes of less active producers.

Importance of local networks

Communication frequency and trust in contacts. We asked producers about the number of times they had contacted different organizations in the last year, as well as the average level of trust that they had in these organizations based on an 11-point Likert scale (fig. 2). In the case of the Conditional Waiver, the Regional Board is considered the most important regulatory agency because it has the authority to manage and enforce the program. The diffusion network consists mostly of local agencies that deliver information about policies and practices to individual producers, as well as the regional organizers of the SVWQC. The agricultural commissioners are considered a diffusion agency because despite having formal regulatory duties, they are usually viewed as ombudsmen who help producers comply with pesticide laws.

The diffusion network agencies received much higher levels of trust and contact (e.g., 58% of respondents contacted agricultural commission-



In 2004, about 50% of Sacramento River Valley orchard growers surveyed were using, *left*, vegetated strips to filter and reduce runoff and lessen spray drift from their fields to nearby waterways. Only about 18% had adopted pheromone mating disruption to control various insect pests; *right bottom*, Hercon pheromone flakes, used to disrupt insect mating, are applied by helicopter, *right top*.

ers at least once) than the regulatory agencies (15% contacted the Region 5 board at least once) (fig. 2). Trust and contact were also positively correlated. Even diffusion agencies with fairly low levels of contact, such as the California Department of Food and Agriculture (15% of farmers contacted at least once) and two of the regional coalition organizers (CURES and Ducks Unlimited [10% and 14% contacted at least once, respectively]), had higher levels of trust than might be expected, given their lower frequency of contact by growers. Just the basic descriptive data about trust and contact shows how the local diffusion network interacts most effectively with farmers with respect to water-quality management.

Explaining policy satisfaction, participation and practice adoption. We conducted a series of regression analyses to estimate how many times a grower would need to have contact with the diffusion network before leading to a change in three dependent variables associated with successful water-quality management: (1) participation in coalition activities; (2) satisfaction with coalition group policies; and (3) the number of orchard BMPs on a particular farm. The participation measure was a count (range = 0-9) of the number of watershed activities producers had engaged in, varying in intensity from reading brochures to committee membership.

The satisfaction measure took the average level of agreement to four questions (on a 7-point scale, where 1 = strongly agreed and 7 = strongly disagreed) about coalition effectiveness for addressing water-quality problems, encouraging the participation of other producers, pooling resources and facilitating BMP adoption. The orchard BMP measure was a count of 11 (range = 0–11) different practices considered to be protective of water quality.

Measuring network density and control variables. To measure the density of network contacts, we counted the number of organizations contacted by the producer from the diffusion network (range = 0-14) and the regulatory network (range = 0-6). The analysis controlled for a range of other variables that are considered by diffusion-ofinnovation models, which are typically used to predict the adoption of agricultural practices. These variables included the producer's education level, their operation's income and the total number of acres farmed (rented plus owned). For the nonorchard sample, we measured perceptions about the severity of water-quality problems, the likelihood that agricultural sources are causing a problem, and the availability of information about the coalition groups. Due to nonresponse on the attitude and belief questions, multiple imputation by chained equations (MICE) was used to

estimate missing data on these variables (see www.multiple-imputation.com for methodological details). For the orchard sample, we asked if the respondent was aware that pesticides have been detected in the Sacramento River and if they have been informed of water-quality management practices (table 1).

Adoption of best practices. Before reporting the results of the regression analysis, we summarize the rates of practice adoption (table 1). The results suggest that adoption rates partly reflect the combination of experience with each practice and the balance between economic risks/costs to crops and environmental protection. For example, some of the conventional pest-management practices, such as basing the time of spraying on weather/wind (reported by 88.4% of orchard growers), have been a part of agricultural research and education since the 1960s, and more is known about how to adapt these practices to specific farm settings to protect water quality while simultaneously controlling pests and reducing overall input costs (O'Connor-Mayer 2000). Alternative pest-management practices, such as providing beneficial insect habitat (reported by 30.8% of the orchard growers), on the other hand, are relatively new and are more complex in terms of their research development and adaptation to on-farm use. There is more uncertainty about their readiness for

TABLE 2. Regression models for policy satisfaction and coalition participation*

	Dependent variables		
Independent variables	Policy satisfaction	Coalition participation	
Policy network exposure			
Diffusion network	0.05 (0.02)†	0.27 (0.02)†	
Regulatory network	-0.02 (0.04)	-0.06 (0.06)	
Operation/operator characteristics			
Education	-0.06 (0.03)†	0.07 (0.04)‡	
Income	0.03 (0.02)	0.11 (0.03)†	
Total acres (100s)	0.002 (0.001)	-0.002 (0.002)	
Water-quality attitudes and beliefs			
Perceived severity of water-quality problems	0.01 (0.03)	-0.07 (0.04)‡	
Perceived likelihood of agricultural causes	0.07 (0.03)†	0.01 (0.04)	
Coalition group information availability	0.25 (0.04)†	0.02 (0.04)	
Other parameters			
Constant	3.64 (0.20)†	1.85 (0.26)†	
Model fit	Adj. R ² = 0.11, F = 16.84†	Adj. R ² = 0.21, F = 36.58†	
* Cell entries are estimates of unstandardized linear regression slope coefficients.			

* Cell entries are estimates of unstandardized linear regression slope coefficients,

with standard errors in parentheses.

† Reject null hypothesis of coefficient = 0 at P < 0.05.

 \ddagger Reject null hypothesis of coefficient = 0 at P < 0.07.

use, and about balancing their efficacy at reducing pests and associated crop risks with their environmental benefits (Kogan 1998).

Respondents reported moderate adoption rates of runoff-control practices, such as filter strips (reported by 50% of orchard growers). These practices are thought to pose few economic risks to crops, but to have fairly clear benefits for reducing the amount of agricultural contaminants entering surface water from dormant-season orchard sprays (Zalom et al. 2002). An exception is that orchard floor vegetation, depending upon how it is managed, influences orchard temperatures and may increase the potential for freeze damage in orchard crops (Snyder and Connell 1993).

Network contacts needed for change. Tables 2 and 3 summarize the results of the regression analysis by presenting unstandardized coefficients, which are interpreted as the expected change in the dependent variable (for example, policy satisfaction) for a one-unit change in an independent variable (for example, number of diffusion network contacts), controlling for the other independent variables. Diffusion networks have an important influence on all three dependent variables; the estimated diffusion network coefficients are positive and are statistically different from zero in all models (tables 2 and 3).

Unlike correlation coefficients, regression coefficients are not constrained to the range between negative and positive one (–1 to +1); their importance must be judged relative to the scales of the variables. To assess their influence on each dependent variable, it is useful to calculate how many additional diffusion network contacts are required to increase the dependent variables by one unit. The fewer the contacts needed, the more power each contact has for changing the relevant outcome.

In our survey, we found that the number of contacts needed to change different measures of policy effectiveness was highest for satisfaction with coalition group policies — it takes 20 diffusion network contacts to increase policy satisfaction by 1 point on the 7-point scale. However, the influence of diffusion networks was quite strong for coalition participation and BMP adoption. It took 9.0 additional diffusion network contacts for the adoption of an additional orchard BMP, and 3.7 contacts for another act of coalition participation. Overall, diffusion networks had the strongest influence on coalition group participation, followed by BMP adoption, and weakest (but still significant) for policy satisfaction. Contact with the regulatory network, on the other hand, had zero influence on the three dependent variables.

Other variables. The coefficients for the other independent variables — such as operator characteristics and attitudes and beliefs toward water quality — were largely consistent with classic diffusion-of-innovation models (Rogers 2003). Producers who thought that agriculture influences water quality and who had information about coalition group practices had higher levels of policy satisfaction. Producers who had more education

TABLE 3: Reg	ression mo	del for o	orchard
nvironmental	best manad	ement	practices*

Independent	Unstandardized	
variables	coefficients	
Policy network exposure	e	
Diffusion network	0.11 (0.04)†	
Regulatory network	0.01 (0.09)	
Operation/operator cha	racteristics	
Education	0.03 (0.06)	
Income	0.14 (0.05)†	
Total acres (100s)	0.004 (0.004)	
Water-quality attitudes	and beliefs	
Pesticide awareness	0.65 (0.22)†	
Practices awareness	0.70 (0.27)†	
Other parameters		
Constant	2.94 (0.33)†	
Model fit	Adj. R ² = 0.22, F = 14.48†	
* Cell entries are estimates of unstandardized linear regression slope coefficients, with standard errors in parentheses.		
t Reject null hypothesis of coefficient = 0 at $P < 0.05$		

and higher incomes were more likely to participate, and higher income producers also had implemented more BMPs. Because there was a strong correlation between agricultural income and size of operation, the total-acres variable became significant in regressions that omitted the income variable. This suggests that larger and wealthier operations were more likely to participate in watershed management and to adopt BMPs. Orchard growers who were aware of pesticide problems and practices were also more likely to implement BMPs.

The most incongruous finding was that producers who thought that water quality is *not* a problem were more likely to participate in the coalition group activities, and more-educated growers were less satisfied with coalition policies. This suggests that an important motivation for participation by educated growers was to prevent the implementation of costly new policies for water-quality problems, which many producers perceived to be of lesser importance than other issues, such as urbanization. According to our personal interviews (see below), this type of "policy skepticism" is likely to shift toward problem-solving if waterquality monitoring conducted by the coalition clearly establishes a relationship between agricultural practices and water pollution.

Networks enhance sustainability

Agricultural water-quality management is an important example of sustainability in action. Our empirical analyses of grower attitudes and behaviors demonstrate that local diffusion networks enhanced the effectiveness of the SVWQC. The more producers interacted with diffusion networks, the more likely they were to be satisfied with watershed management policies, participate in policy activities and adopt environmentally sound management practices, as long as they were cost effective.

To further validate our results, we conducted on-farm, personal interviews with more than 20 Sacramento River Valley producers involved with waterquality management. The following quotes illustrate the pathways that are essential to promoting sustainability:

- "The coalitions are good to have because not only do they get the opinions of everybody, but they also provide for accurate information dissemination." — Glenn County producer, on information diffusion
- "Through the coalition group we've had very good success because people know that we're part of the community, that we're not there to control them, but to help them. They trust me better than they do the guy in Sacramento." — Shasta County producer, on social capital
- "People are resistant to change and may not be convinced that change is needed. Part of the job of the coalitions is outreach. There will be friction between growers but people will change their minds by talking to neighbors and seeing the practices work." — Glenn County producer, on cultural change

We feel that these findings are strong enough to emphasize to policymakers the importance of recognizing how government decisions can weaken or strengthen these local diffusion networks. Any dismantling of diffusion networks represents a loss of human and social capital, and capacity for cultural change, which severely degrades the ability to integrate sustainability principles into agricultural policy and decision-making.

A variety of evidence suggests that recent policies have decreased the investment in such networks. For example, California agricultural commissioners are local agencies that perform a variety of programs and duties in each county. Historically, their core programs have included pesticide-use enforcement, quarantine, pest detection, pest exclusion, weights and measures programs, and outreach. In recent years, some noncore programs of the agricultural commissioners' offices have extended into land-use planning and natural resources management. In our survey, the agricultural commissioners were identified as the most trusted and most frequently contacted source for information about water quality. However, while their noncore programs and duties have expanded, funding sources have generally failed to keep pace with new programs and responsibilities, including water quality (personal communication, M. Black, Glenn County agricultural commissioner, March 2007).

Another example is that the two main federal funding sources for landgrant university agricultural outreach programs — Agriculture Experiment Stations (1887 Hatch Act) and the Cooperative Extension system (1914 Smith-Lever Act) — increased by only 4.8% and 1.6%, respectively, from 1996 to 2006, whereas costs inflated at a much higher rate. Although the full impact of these flat budgets depends on state and local decisions, they have contributed to significant decreases in local diffusion networks in California and

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several important agricultural states. Likewise, from 2002 to 2004, California lost 152 county Cooperative Extension positions in 20 different counties. A final example is federal Farm Bill policies that influence local funding for the Environmental Quality Improvement Program (EQIP), which is administered throughout the United States by the Natural Resources Conservation Service and in conjunction with local resource conservation districts.

This analysis has limits as a case study in sustainability. The Conditional Waiver program in California is still too new to have achieved long-term success, has a relatively limited geographic scope and focuses mostly on the environmental aspects of sustainability. However, local diffusion networks will continue to be important to the future of these programs in California; they will also play a central role wherever sustainability involves policies that require innovation, collective action and cultural change.

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New late-season navel orange varieties evaluated for quality characteristics

by Tracy L. Kahn, Ottillia J. Bier and Robert J. Beaver

New early- and late-maturing navel orange varieties have expanded the navel orange season for California's domestic and export fresh-fruit market. For 5 years, we evaluated the fruit-quality characteristics of purported late-season varieties imported from Australia to determine whether they have any advantages over Lane Late, the first late-season navel orange imported from Australia and grown in California. Of the six varieties evaluated, Autumn Gold, Barnfield, Chislet. Powell and Lane Late had late-maturing characteristics, but none of these varieties stood out as having the latest maturing fruit for all traits associated with maturity at all nine locations studied. For certain locations, sample dates and years, there were significant differences among the varieties for quality traits associated with maturity, such as solids-to-acid ratio, percentage acidity and puncture resistance, but these differences varied depending upon location.

F or most people, a navel orange is a navel orange. Most consumers are not aware that throughout the year, the navel orange bin in the grocery store may contain as many as 22 commercial varieties. The increased number of varieties that reach legal maturity earlier or later than the Washington navel variety, which has been the standard since the late 19th century in California, has had a dramatic effect on the fresh orange market. Over the past few years, the return to growers for Valencia^{*} oranges has dropped in California, resulting in a reduction in Valencia acreage. This is due in part to the importation of late-season navel



Researchers with the Citrus Variety Collection at UC Riverside (shown) evaluated the quality characteristics of late-maturing navel oranges grown here and at collaborating orchards around California.

oranges from Australia and to recent new plantings of late-season navel varieties in California, which are more highly colored and easier to peel than Valencia oranges (NASS 2006). The introduction of new late-season navel orange varieties has extended the season for navel oranges in California's domestic and export fresh fruit market.

The majority of new navel varieties originate from a mutation or genetic change in a vegetative bud, commonly called a "bud sport" or "limb sport." The selection of a bud sport with altered fruit or tree characteristics, such as a change in the timing of fruit maturity, is the most common method for developing new orange varieties. This is a different process from conventional citrus breeding, which involves crossing selected parents and then selecting potentially promising hybrid seeds that result from recombination of the genes during sexual reproduction.

Selection of bud sports

For types of citrus that do not normally produce seeds, such as navel and Satsuma mandarin oranges, the selection of potentially desirable bud sports is the only viable means of developing new varieties. The selection of bud mutations from the Washington navel orange has resulted in most of our current varieties, such as Thomson, Carter, Gillette, Newhall, Atwood, Bonanza, Fisher, Beck and Cara Cara, a navel orange with pink flesh like that of a red grapefruit.

In California, the Citrus Clonal Protection Program (CCPP) — a cooperative program between the UC Riverside Department of Plant Pathology and California citrus growers, represented by the California Citrus Research Board (CRB), California Citrus Nursery Board and California Department of Food and Agriculture (CDFA) — provides a safe mechanism for the introduction of citrus varieties into the state from any citrus-growing area of the world (www.ccpp.ucr.edu). Approximately 90% of the new varieties introduced by the CCPP originated as bud sports of other varieties. One such variety is Lane Late, a late-maturing Australian bud sport of Washington navel that was introduced into California in 1973. Comparison of Lane Late fruit with that of the Washington, Newhall, Fisher and Atwood varieties found that Lane Late holds on the tree much better than the midseason varieties

TABLE 1: Rootstocks and interstocks for varieties grown at nine cooperator locations

Parent and Atwood and early-maturing strains such as Fisher and Newhall (Nauer et al. 1990).

Lane Late is now an important commercial navel-orange variety in California, Australia and other citrus-production regions of the world. The success of the late-season navel orange market in Australia, which paid higher returns for Lane Late, coupled with plant-breeders-rights legislation in Australia permitting the patenting of new navel varieties, encouraged Australian growers to search for new late-maturing navel orange varieties in the early 1980s.

A number of new late-maturing navel orange selections were identified by Australian growers and evaluated by Gallasch (1996, 1997). Comparisons of these late-hanging selections in Australia demonstrated small but significant fruit-quality differences in some years and not others. For example, midto late-season varieties that had the best internal fruit quality based on total soluble solids were Wiffen, Powell, Summer Gold, Hutton, Christensen and Autumn Gold. Late in the Australian season (December), Wiffen, Lane Late, Wilson, Powell and Hutton had the highest acid contents, which is associated with good flavor (Gallasch 1996, 1999).

In the late 1980s and early 1990s, five (Autumn Gold, Barnfield, Chislett, Powell and Summer Gold) of the 12 varieties evaluated in Australia were sent to the CCPP for guarantine and then released for propagation in California in 1991 and 1992. The California Citrus Nursery Society (CCNS) agreed to facilitate the testing of these late navel varieties, which are currently licensed in California. Most of the nurseries that participated in testing these selections top-worked (with buds of the new variety grafted onto the former scion, now called "interstock") two existing trees with Autumn Gold, Chislett, Powell, Summer Gold and Lane Late budwood. In 1996, in cooperation with the CCNS and five cooperating citrus nurseries, our laboratory began the first extensive fruit-quality evaluations of these varieties in California. In 1997, two additional nurseries agreed to collaborate at multiple locations.

The top-worked trees at collaborating nurseries differed in rootstocks and interstocks (table 1). These differences

Cooperator location	Varieties	Interstock	Rootstock
Madera*	All except Barnfield	Frost nucellar navel	Trifoliate
Orange Cove	All except Barnfield	Valencia	Troyer
Woodlake	All except Barnfield	Washington navel	Trifoliate
Lindsay	Barnfield, Lane Late	None	Carrizo
Ducor	All except Barnfield	Atwood	Carrizo
Delano	Barnfield only	None	Carrizo
Arvin	All except Barnfield	Brazilian Sour	Troyer
Ojai	All except Barnfield	None	Carrizo
Fillmore	All except Barnfield	None	Carrizo
In Madera Lane Late trees were	on Carrizo rootstock with no intersto	ck	



The late-maturing navels were developed from bud sports — genetic changes in vegetative buds — of Australian varieties. Lane Late has been an important late-maturing commercial variety in California since the 1970s, but others are being planted.

are known to affect tree performance and fruit-quality factors such as soluble solids, acid concentration and their ratio; however, when we began this study, these were the only trees available for evaluation in California (Castle 1995). To date, this is the largest and longest study in the United States evaluating these late-season navel orange varieties from multiple locations.

Evaluating fruit quality

The eight cooperating nurseries covered a 220-mile span from north to south in the San Joaquin Valley and Central Coast: Madera, Orange Cove, Woodlake, Ducor, Delano, Lindsay, Arvin, Ojai and Fillmore (table 1). All sites except two (Lindsay and Delano) contained the following late navel selections: Autumn Gold, Chislett, Powell, Summer Gold and Lane Late. One of the remaining sites was planted exclusively to Barnfield (Delano), and the other was planted to Barnfield and Lane Late (Lindsay). Two trees of each variety per site were available for sampling, except for the two sites planted to Barnfield. At that site, six trees were sampled and at the remaining site, four Barnfield and two Lane Late trees were sampled. The cultural practices at each grower-cooperator site were essentially the same.

Trees from each site were sampled three times in 1996 starting January 1996, and four times per season at the same time each year from 1997 to 2001, when fruit was available: (1) late February/early March, (2) late March/early April, (3) third week of May and (4) late June/early July. After the first year of the study, the January sample date was eliminated and the late February and late June/early July



Fig. 1. Percentage titratable acidity data, pooled over 1996–2001 and multiple locations for five sample dates.



Fig. 2. Puncture-resistance data, pooled over 1997–2001 and multiple locations for four sample dates.

sample dates were added. The inclusion of nine sites, multiple sampling periods per year, and statistical analysis of the data from the seven sites that had the same five varieties, allowed comparison of both differences among selections overall and differences among selections at a particular locale.

We sampled 10 representative fruits from each tree at random positions in the tree canopy from all locations over a 2-day period, then transported the fruit to our lab, where samples were analyzed. We measured the length, width, weight and rind thickness of each sample. Puncture resistance, a test of rind firmness, was measured in grams on a custom-fabricated penetrometer, or puncture meter, which consists of a Chatillion spring push gauge, a maximum force indicator and a 0.040-inch-diameter cylindrical tip (Coggins and Lewis 1965). The cut surface of each fruit was visually evaluated for the percentage that was granulated. (Granulation is an internal physiological disorder of sweet oranges, grapefruit and some mandarins, characterized by enlarged, hardened and nearly colorless juice vesicles [Erickson 1968].)

Rind color and texture and internal color of the fruit were evaluated by correlation to standard color and texture charts. Seeds from the fruit of each sample were counted and the fruit was juiced with a Sunkist extractor. The juice from each 10-fruit sample was weighed and the percentage of juice calculated. The extracted juice was also analyzed to determine the percentage of soluble solids, mostly sugars, using an Atago PR-100 digital refractometer. The percentage of acid was determined based on citric acid by titration of a juice aliquot to pH 8.3, with the aid of a pH meter. These percentages were also used to calculate the soluble solidsto-acid ratio. In California, the ratio of percentage soluble solids to percentage acid is one of the standards used to determine the legal maturity of oranges; a ratio of 8 to 1 or greater is considered mature (Barclays 2002).

Maturity-related characteristics

Maturity. Although we measured several diverse traits, it was not surprising that the consistently differing characteristics among these late navel

orange varieties were related to maturity, since the bud sports were selected because they produced late-maturing fruit. When the data was averaged over all locations, some general trends were evident, but they did not take into account differences in the characteristics among locations or sample dates. Based on soluble solids-to-acid ratio data, Autumn Gold, Barnfield, Chislett and Lane Late fruit reached legal maturity around mid-January, up to 4 weeks later than Washington navel; Powell matured slightly later. On the other hand, Summer Gold fruit reached legal maturity in late December to early January, approximately the same time as Washington.

Soluble solids and acid. The soluble solids-to-acid ratio is used as a legal standard for oranges because both soluble solids and titratable acidity are closely associated with the quality of the fruit. As the fruit grows, the soluble solids concentration gradually increases and acidity decreases. In California, the acidity of mature oranges usually ranges between 1.0% and 1.3% (Sinclair 1961). When the acid level drops much lower, fruit tastes sweet but bland.

For all of the varieties evaluated, the percentage titratable acidity became progressively lower from the late January sampling date in 1996 and those from February/March through June/July from 1997 to 2001 (fig. 1). When the data was pooled over all locations and years, the percentage of titratable acids after the late January sample date was similar among Autumn Gold, Barnfield, Chislett and Lane Late fruit, but slightly higher in Powell (fig. 1); Summer Gold was considerably lower at each of the sample dates from late January to June/July. At the June/July sample date, when the data for all locations was pooled, all of the varieties had acid percentages between 0.4 and 0.5. The lower acid percentage of Summer Gold fruit at each sample date resulted in an overall higher soluble solids-toacid ratio for this selection relative to the others (data not shown). Summer Gold's lower acid level is further indication that it matures earlier than the other selections.

Rind-softening. When the rind of navel oranges changes from green to or-

ange, it begins to soften and continues to soften as the fruit matures and during postharvest storage (El-Otmani et al. 2000). Legal maturity actually occurs after rind-softening begins, but the rind continues to slowly soften as long as fruit hangs on the tree. Rind that is very soft is an indicator of overmature fruit. Softening rind is more susceptible to disorders such as rind staining, water spot and decreased resistance to decay from *Penicillium* and *Geotrichum*, which reduce preharvest fruit life, postharvest storage time and market value (El-Otmani et al. 2000).

At the second fruit sample date between 1997 and 2001 (late February/ early March), fruits had firm rinds that were resistant to puncture and had higher values (350 to 400 grams) for puncture resistance. Puncture resistance values decreased (< 300 grams) as the rind softened throughout the season (fig. 2). When the puncture resistance data for fruit of all the varieties was averaged over all locations for all sample dates, all of the varieties except Summer Gold had fruit of similar firmness. When the puncture resistance data was averaged over all locations and years for the last three sample dates, Autumn Gold, Lane Late and Powell fruit had intermediate rind firmness and Chislett and Barnfield fruit had slightly firmer rinds. Summer Gold had considerably softer rinds than all other varieties for all sample dates (fig. 2).

Granulation. Although it is not a measure of fruit maturity, granulation occurs most often in fruit picked late in the season. It usually starts near the stem end and extends into the region closest to the core. The walls of the juice sacs thicken and stiffen, finally producing a dry, woody condition in the affected part of the fruit. Rapidly growing fruit and larger fruit have a greater tendency to granulation. Granulation varies from year to year. There was no evidence of granulation during 1999 and 2000; during 1996 and 2001, small percentages of fruit were granulated; and in May 1997 and 1998, much higher percentages of fruit were granulated. The highest levels of granulation occurred in May 1997. Because the granulation data was limited, the condition was not analyzed statistically.

In May 1997, 41% percent of Lane Late, 26% of Powell, 16% of Summer Gold and 15% of Autumn Gold fruit exhibited granulation; no Barnfield fruit were available for evaluation. In May 1998, both Lane Late and Barnfield had the highest levels of granulation (28%); Powell fruit had slightly less (22%); and Chislett (18%), Summer Gold (10%) and Autumn Gold (4%) had considerably less granulation. However, Barnfield fruit was evaluated at two locations whereas the others were evaluated from seven locations.

Other fruit characteristics

Although these navel varieties were chosen for lateness in maturity, they differed slightly in other fruit characteristics not related to maturity. When data for each variety was pooled over locations and years, characteristics related to fruit size, such as weight, width and length, differed among the varieties. Barnfield had the largest average weight, length and width of all the varieties evaluated for the three sample dates from February/early March through mid-May. For example, our calculation of the average number

of fruit per packed carton, based on average fruit width for pooled data from the May 1998 sample date, indicated that Barnfield fruit were designated as "48s," whereas all other varieties were "56s." Barnfield fruit had weights similar to Chislett and Powell for the June/July sample dates.

In addition, Chislett and Powell fruit were slightly heavier on average than Lane Late, Autumn Gold and Summer Gold for all of the sample dates. Barnfield fruit also had slightly thicker rinds than the other varieties, but rind thickness is related to fruit size because larger fruit tend to have thicker rinds. However, Barnfield fruit were sampled from fewer locations than the other varieties, which may account for some of the difference.

Data pooled over locations and years for the ratio of fruit length-to-width confirmed our observations that Summer Gold fruit were slightly rounder than the other varieties. Other external traits such as rind color and texture were similar among the varieties for all sample dates. The juice percentages (a measure of fruit juiciness: juice weight divided by fruit weight) were also similar among the varieties for all sample dates, but all varieties had slightly lower juice percentages after the late January sample date. The percentages remained at or slightly below 50% through the June/ July sample date.

TABLE 2A. Two-way ANOVA for fixed effects of location and variety on solids-to-acid ratio of juice for two locations representing typical results									
	May 2000 May 2001								
Source	DF	MS	Р	DF	MS	Р			
Location (L)	6	185.7470	0.000	6	355.3870	0.000			
Variety (V)	4	60.1570	0.000	4	144.1710	0.000			
$L\timesV$	24	12.2110	0.000	24	22.0280	0.006			
Error	35	3.0450		35	8.7020				
Total	69			69					

TABLE 2B. Tukey's pairwise comparisons of means amo	ong varieties within locations
for solids-to-acid ratio of ju	ice

	May 2000							May 2001					
Location	Autumn Gold	Chislett	Lane Late	Powell	Summer Gold	Autumn Gold	Chislett	Lane Late	Powell	Summer Gold			
Madera	18.99a*	19.71a	19.61a	18.37a	21.56a	28.15a	29.19a	23.22a	21.69a	27.37a			
Orange Cove	21.50b	22.26b	23.08ab	21.39b	27.99a	24.58bc	21.77bc	30.16ab	20.96c	36.52a			
Woodlake	22.98a	22.89a	18.98a	20.03a	23.69a	25.46b	30.59ab	28.35ab	28.24ab	36.71a			
Ducor	22.02ab	21.90ab	17.82b	19.37b	25.53a	28.38b	27.36b	24.29b	23.01b	38.69a			
Arvin	26.40c	28.89bc	33.18b	25.18c	39.39a	30.07b	32.01b	32.63b	28.84b	41.69a			
Ojai	14.29b	17.38ab	20.98a	15.92b	17.27ab	17.51a	18.13a	10.81a	16.83a	19.28a			
Fillmore	19.97ab	15.91b	21.16a	18.54ab	21.59a	19.68a	17.53a	19.15a	18.109a	18.25a			
* Different letters represent significant differences at $P < 0.05$.													

Differences among locations

Data for 15 of the fruit-quality characteristics collected from February 1998 to May 2001 for all varieties (except Barnfield) was analyzed using twoway analysis of variance (ANOVA) to investigate differences among locations (tables 2A and 3A). Because fewer experimental sites were available early in the study, and because Barnfield fruit were available at only two of the sites, not all of the data could be analyzed for statistical differences. When the interaction of locations by varieties was significant, the data was analyzed by Tukey's procedure to separate significant differences among varieties within locations (tables 2B and 3B).

For all of the sample dates except those in 1999, significant statistical differences existed among locations for all traits. Only two coastal locations with fruit were available in 1999 due to a major freeze in December 1998 that affected fruit in the San Joaquin Valley. The significant statistical differences among the locations were not surprising because the trees were exposed to different climatic conditions, altitude, rootstocks, and interstocks (tables 2A and 3A). All of the traits evaluated had significant statistical differences among the varieties for at least three of the 15 collection dates. However, for most of the traits, these differences were not consistent from year to year or for a particular sample date. Characteristics associated with maturity — such as puncture resistance, percentage soluble solids, percentage acidity and the soluble solids, percentage acidity and the soluble solids-to-acid ratio — had statistically significant differences among the varieties for all or most of the collection dates (tables 2A and 3A)

Varieties varied significantly

Significant differences among varieties for a particular trait at a particular sample date do not tell the whole story; nor do the results of pooled data.

For certain collection dates and characteristics, there were statistically significant interactions of location by varieties, which allowed the separation of significant differences among varieties within collection locations (tables 2A and 3A). In many cases, the differences observed when the data for the locations was pooled were not significantly different when individual locations were analyzed. For example, when the data for all locations was pooled, although Summer

TABLE 3A. Two-way ANOVA for fixed effects of location and variety on percentage acidity of juice for two locations representing typical results

		February 20	000		May 2000	
Source	DF	MS	Р	DF	MS	Р
Location (L)	6	0.0887	0.000	6	0.0770	0.000
Variety (V)	4	0.0270	0.000	4	0.0184	0.001
$L\timesV$	24	0.0079	0.036	24	0.0086	0.004
Error	38	0.0042		35	0.0032	
Total	72			69		

Gold fruit appeared to mature earlier and Powell slightly later based on solids-toacid ratio data, this was not always the case for individual locations. For most locations and sample dates, Summer Gold had higher solids-

TABLE 3B. Tukey's pairwise comparisons of means among varieties within locations for percentage of juice

	February 2000					May 2000					
Location	Autumn Gold	Chislett	Lane Late	Powell	Summer Gold	Autumn Gold	Chislett	Lane Late	Powell	Summer Gold	
Madera	0.80a*	0.77a	0.82a	0.77a	0.76a	0.63a	0.60a	0.62a	0.64a	0.56a	
Orange Cove	0.74a	0.65a	0.57a	0.70a	0.58a	0.60a	0.56a	0.53a	0.57a	0.50a	
Woodlake	0.81a	0.78a	0.70a	0.70a	0.77a	0.53b	0.56ab	0.71a	0.60ab	0.60ab	
Ducor	0.75a	0.77a	0.77a	0.82a	0.68a	0.60a	0.56a	0.62a	0.66a	0.50a	
Arvin	0.68ab	0.76a	0.76a	0.75a	0.54b	0.53a	0.50a	0.41a	0.49a	0.37a	
Ojai	0.92ab	0.92ab	0.93ab	1.03a	0.81b	0.74a	0.68a	0.79a	0.77a	0.71a	
Filmore	0.74c	0.99a	0.89abc	0.94ab	0.79c	0.66bc	0.87a	0.56c	0.72a	0.56c	
* Different letters represent significant differences at P < 0.05.											

to-acid ratios than the other varieties. However, depending on the location, Summer Gold did not always have significantly higher solids-to-acid ratio than other varieties (table 2B).

In May 2000, Summer Gold fruit from Fillmore had a significantly higher solids-to-acid ratio than Chislett, but there were no significant differences among the other varieties. However, on the same date, Summer Gold fruit from Orange Cove had a significantly higher solids-to-acid ratio than Chislett, Autumn Gold and Powell but not than Lane Late, and there were no significant differences among Chislett, Autumn Gold and Powell (tables 2A and 2B). For each of the locations except Arvin and Orange Cove, there was at least one sample date when no statistically significant differences occurred among the varieties in timing of maturity based on solids-to-acid ratio (table 2).

When the location data for percentage acidity was pooled, the general trend from one year to next was that the acid levels in fruit were similar among Autumn Gold, Chislett and Lane Late, but slightly higher in Powell and considerably lower in Summer Gold. This was not always the case when data for individual locations was analyzed. At most locations and for most sample dates, Summer Gold had the lowest or one of the lowest acidity percentages, and for some locations and sample dates, Powell had the highest acidity (tables 3A and 3B).

Fruit grown at different sample dates, years and locations varied in whether there were significant differences among the varieties for percentage of acidity. For fruit sampled from Ojai in February 2000, Summer Gold had significantly lower percentage acidity than Powell but not than the other varieties. Yet fruit sampled from the same location in May 2000 had no significant differences (table 3B). In contrast, there were no significant differences in percentage acidity between fruit sampled from the two northernmost locations, Madera and Orange Cove, for the February 2000 and May 2000 sample dates (table 3). For all locations, there was at least one sample date when there was no significant difference for percentage acidity in the fruit (tables 3A and 3B).

Puncture resistance, a measure of rind firmness, showed similar trends, with significant interactions of location by variety. The relationship among varieties differed depending upon where they were sampled, and also collection date. For most sample dates and locations, Summer Gold fruit had the lowest average puncture-resistance values, and in some cases this was significantly different from one or more varieties. For other sample dates and locations, there were no significant differences among any of the varieties.

General trends in late navels

Overall, some general trends were apparent. Autumn Gold, Barnfield, Chislett, Powell and Lane Late had late-maturing characteristics that would extend the navel orange season. When the data was pooled over locations and years, Chislett and Barnfield had slightly firmer rinds than Autumn Gold, Powell and Lane Late, but based on pooled solids-to-acid ratio data, and percentage of titratable acidity (a component of the solids-to-acid ratio), Powell fruit matured slightly later and had slightly higher acidity. Yet no variety stood out as having the latestmaturing fruit for all traits associated with maturity for all locations. For certain locations, sample dates and years, there were significant differences among the varieties for traits associated with maturity, but these differences varied by location. In general, Summer Gold fruit matured earlier. However, for certain locations, sample dates and years, no significant differences existed for late-maturing characteristics.

One of the questions we set out to address was whether these new varieties have any advantages over Lane Late, the first commercial lateseason navel orange variety grown in California. Even though Lane Late had late-maturity characteristics, during those seasons when granulation occurred, the new varieties (including Summer Gold), generally had a lower percentage of granulated fruit than Lane Late. The prevalence of granulation can have a dramatic effect on the amount of marketable fruit, so these new varieties warrant consideration for future plantings. Another trend,



Lab assistants Juliana Lee (left) and Aundria Cherise Davis analyze orange samples at the UC Riverside laboratory.

although unrelated to lateness in maturity, was fruit size. Fruit size can be "very large" if fruit is held late. This can be an advantage for locations where small fruit size is a frequent problem. Barnfield, evaluated at only two locations, had particularly large fruit.

Given the differences in fruit characteristics at different locations for various sample dates and years, growers should consider planting more than one of the varieties with late-maturing characteristics to determine which best suits their growing conditions.

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Clean water, scarce water

The quality and scarcity of water are critical issues facing the nation, and world. In the United States, more than 100 miles of coastline, 680 acres of lakes and reservoirs, and 1,700 miles of rivers and streams are listed as impaired by disease-causing pathogens (such as Cryptosporidium parvum, Salmonella and Escherichia coli O157:H7). Likewise, competition and demand for clean water — for drinking, wildlife and irrigation — has never been greater, while global climate change threatens to cause severe water shortages. In the next issue of the peer-reviewed California Agriculture journal, UC researchers examine the role of wetlands and vegetated buffers in mitigating pathogens in runoff from irrigated livestock pastures in the Sierra Nevada foothills. In addition, researchers examine the impact of western juniper — a water-intensive shrub that has become widespread over the past 130 years - on surface-water supplies in the Klamath Basin.



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