

# California Agriculture

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Agricultural easements:  
New tool for farmland protection



## Agricultural easements: A farmland preservation tool



W.R. GOMES  
Vice President  
Agriculture and  
Natural Resources

**AS** California's population grows, the pressures to subdivide and develop farmland increase. A recent UC Agricultural Issues Center (AIC) study reported that 497,000 farmland acres were converted to urban uses between 1988 and 1998, as population rose by 5.4 million (19%).

The AIC study translated that figure to the development of 0.1 acres of farmland, on average, for each new resident. California's population is projected to grow to 58.7 million by 2040. If the same rate of development

were to continue, the population increase would result in conversion of about 2.5 million acres of farmland to urban use by 2040 — about 10% of the 27 million acres of private farmland now in the state.

Furthermore, direct urbanization is only one form of farmland loss. Acres may be removed from production for other reasons, such as: the transfer of water from farming to environmental or urban uses; the steady expansion of wildlife habitat and wetlands restoration programs; and the retirement of land which is no longer agriculturally viable, such as salt-laden acres in western San Joaquin Valley that lack effective drainage.

Californians are exploring a variety of ways to minimize farmland loss, including "smart growth" measures that encourage more intensive urban development. For many landowners and community leaders in California, however, agricultural easements are rapidly becoming the preferred tool for protecting farmland.

In voluntarily selling or donating an easement on an agricultural parcel, a landowner gives up the rights to develop the property for more intensive urban uses, while retaining ownership for all other purposes. In return, the landowner receives cash or tax benefits, or both. As legally recorded restrictions, easements are tied to the land rather than to any individual owner. They are usually designed to exist in perpetuity.

Easement transactions occur between the landowner and a conservation organization, a nonprofit land trust or a public agency. Landowners may like the technique because of its voluntary character and economic incentives, as compared to more conventional regulations such as zoning, growth and municipal boundary controls. Conservation groups and urban residents like the presumed permanency to protect land with agricultural and other open space values.

Easements have been employed for conservation purposes in the United States for more than a century, primarily for protecting unique natural lands such as wetlands, animal and plant habitat, riparian corridors, forests and scenic views. But their application to expressly

maintain land in commercial farming, usually in relation to nearby urbanization, is a relatively recent development. California's first agricultural easement program, Marin Agricultural Land Trust, began in the early 1980s. Since then the technique has proliferated in several parts of the state, although, importantly, not in the Central Valley.

Despite the apparent attraction of agricultural easements, there are serious public policy and practical issues that could limit their widespread application.

**Lasting preservation.** A wise investment means locating easements to carry out particular conservation objectives — whether to protect large blocks of farmland, minimize conversion to urban uses, or redirect the pattern of urbanization away from an area's best farmland. Such strategies call for acquiring easements selectively, avoiding random and isolated easements that in time could be outflanked by urban growth.

**Perpetuity.** Perpetuity is the biggest obstacle to landowner acceptance of easements — the fear of reducing the options of future generations of landowners. Should changed conditions (such as markets, water, labor or regulatory climate) undercut the continuing agricultural viability of an easement-restricted parcel, one argument goes, the affected future landowner should be able to opt out of the arrangement.

**Natural resources.** Because much of California's farmland is a "working" rather than "natural" landscape (including, for example, chemical applications and heavy machinery use), agricultural easements may be incompatible with the protection of natural resources such as wetlands and habitat.

**Funding options.** California's easement programs depend largely on state and federal funding and private foundations, sources external to the counties and regions where most programs operate. Because local governments have restricted tax powers, the ability of communities to buy-in to such preservation programs is limited.

**Conservation agenda.** Nonprofit land trusts — usually grassroots citizen organizations, often with passionate conservation agendas — are generally the principal actors managing easements in California. They have assumed this role because public agencies may lack the funds, expertise and interest to engage in land conservation. Yet land trusts are not formally accountable to the public. Their easement actions, while affecting local land-use patterns, are usually taken independent of community land-use policies.

The UC President's Advisory Commission on Agriculture and Natural Resources has described land-use issues as an area of major importance to the state. In this *California Agriculture*, we examine several aspects of this critical issue. The collection presents a descriptive overview of California's use of the agricultural easement technique, and provides a basis for considering new research in an important emerging area of public policy.



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Executive Editor: Janet White

Managing Editor: Janet Byron

Art Director: Davis Krauter

Circulation Manager: John Fausone

### California Agriculture

1111 Franklin St., 6th floor  
Oakland, CA 94607-5200

Phone: (510) 987-0044; FAX: (510) 465-2659

calag@ucop.edu

http://danr.ucop.edu/calag

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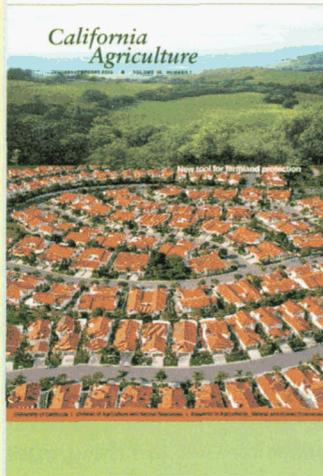
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## In this issue

### FOCUS: FARMLAND EASEMENTS

**On the Cover:** To prevent the creep of urbanization into farmland, about 34 land trusts and open space districts have been pursuing agricultural conservation easements in California. While conservation easements have been used to protect natural resources for many years, the use of easements to protect agriculture is relatively new. The first land trust in the nation specifically targeting farmland (Marin Agricultural Land Trust) was formed in California in 1980. In recent years, easements have grown in popularity as the preferred farmland preservation tool. The top portion of the cover illustration shows the 519-acre Cook property on Sonoma Mountain, where the Sonoma County Agricultural Preservation and Open Space District (SCAPOSD) purchased an easement that restricts future uses of the land to grazing and possible crop production. *Top photo courtesy of SCAPOSD.*

## News departments

# 4

### Science briefs

*Red imported fire ants discovered in Sacramento*

*Nonnative ants disrupt ecosystems*

*California a supercolony of Argentine ants*

*SOD found on UC Berkeley campus*

*Mondavi gift benefits UC Davis wine and food sciences*

### Correction

In the caption on page 68 of the November-December 2001 issue, Julie Price was incorrectly identified. *California Agriculture* regrets the error.

## Research articles

# 26

*Eradication costs calculated . . . Red imported fire ants threaten agriculture, wildlife and homes*

*Jetter, Hamilton, Klotz*

Exotic red imported fire ants will cost households and agriculture between \$387 million and \$989 million annually if they become established.

# 35

*Minimum tillage practices affect disease and yield of lettuce*

*Jackson et al.*

Deep minimum tillage provided better yields and less lettuce drop disease, but tended to decrease soil organic matter, compared to shallow tillage.



### FOCUS: FARMLAND EASEMENTS

## News departments

# 6

### Introduction

*California increases support for agricultural easements*

## Research articles

# 9

*Agricultural easement programs . . . Saving agriculture or saving the environment?*

*Sokolow, Lemp*

Easements have protected open space for a century, but using them for farmland is relatively new; 34 California programs focus on protecting agriculture.

# 15

*Agricultural easements limited geographically*

*Sokolow*

About 120,000 agricultural acres are in easements in California, but many major crop-producing counties do not have active easement programs.

# 21

*Landowners, while pleased with agricultural easements, suggest improvements*

*Rilla*

Landowners in Marin, Sonoma and Yolo counties cited cash, family ownership and conservation as main motivations for selling agricultural easements.

# 22

*Central Valley leaders cautious about agricultural easements*

*Sokolow*

### Red imported fire ants discovered in Sacramento

An infestation of red imported fire ants was discovered at the California State Fairgrounds in Sacramento, the California Department of Food and Agriculture (CDFA) announced in late October. A visitor from Texas reported suspicious-looking ants while staying at Cal Expo's RV park, leading officials to believe that they were brought in on a vehicle or plants.

CDFA spokesman Steve Lyle said that the 20 mounds found at Cal Expo have been treated and officials are hopeful that the ants will not survive the winter. "We believe this is an isolated incident, and not indicative of the ants' spread to Northern California," Lyle said.

Red imported fire ants are an exotic pest first discovered in California in 1997. Native to South America, they have thoroughly infested the southern United States. Extremely difficult to eradicate, they are notorious for their viciousness, swarming out of mounds when disturbed and furiously biting and stinging victims.

The ants pose a danger to homes and residents, agriculture and wildlife habitat; UC scientists estimate that if they became established in California costs could run between \$387 million and \$989 million per year (see p. 26).

Suspected red imported fire ant mounds should be reported to 1-888-4FIREANT. For more information go to: [www.cdfa.ca.gov/phpps/pdep/rifa/](http://www.cdfa.ca.gov/phpps/pdep/rifa/)

### Nonnative ants disrupt ecosystems

By replacing native ants, the tiny black Argentine ant — a well-known household pest — could be disrupting natural ecosystems. A study by UC Davis graduate student Caroline Christian, published in *Nature* (October 2001),

has shown that when key beneficial species are removed by an invading ant, the destructive effects can reverberate through the ecosystem.

Christian,

who is affiliated with the UC Davis Center for Population Biology, studied the fynbos shrublands of South Africa, an area similar in climate and vegetation to the chaparral of California. Wildfires sweep the fynbos every 15 to 30 years, killing most mature plants; new plants grow from seeds buried in the ground by native ants. Christian found that when Argentine ants displace native ants, plants that depend on those ants to bury their seeds do not regenerate after fire.

Seed burial by ants is key to survival for about a third of fynbos plant species, Christian said. When fresh seeds fall, ants are attracted to them and carry them off to bury in their nests. Different ant species specialize in seeds of different sizes: Ants that work cooperatively deal with bigger seeds, while ants that tend to work alone bury smaller ones. If the seeds are not picked up quickly, virtually all are eaten by rodents.

After controlled burning, fynbos areas invaded by Argentine ants showed a tenfold drop in the number of new plants from large-seeded species, compared to uninvaded areas, Christian said. Small-seeded species were much less affected.

### California a supercolony of Argentine ants

In a study published in *Molecular Ecology* (September 2001), scientists from UC Davis and UC San Diego showed that California harbors a huge supercolony of nonnative Argentine ants, extending from Ukiah to beyond the Mexican border.

In Argentina, competition between rival colonies keeps their numbers in check, but most of the California imports recognize each other as family, said Neil Tsutsui, a postdoctoral fellow in the UC Davis Center for Population Biology.

"In ants, usually their biggest competition is within the same species. But here, colonies are so closely related they even exchange workers," said collaborator Andy Suarez, a former UC Davis entomology postdoctoral fellow now at UC Berkeley.

Because they were initiated by a relatively small number of individuals, introduced populations of Argentine ants have reduced genetic diversity and are genetically similar to one another, the scientists found. This close-knit sisterhood allows Argentine ants to form large supercolonies, which then displace native ants and become one of California's leading household and agricultural pests.

Tsutsui and Suarez, working with David Holway and Ted Case at UC San Diego, used a type of DNA fingerprinting to show that Argentine ants in California are genetically similar to ants

Research conducted in the fynbos shrublands of South Africa, below, which is similar to California chaparral in appearance, demonstrates the important role that native ants play in regenerating vegetation after a fire.



Amida Johns

along the southern Parana River in Argentina. Efforts to identify natural enemies of the Argentine ant for biological control should focus on this area, Tsutsui said.

Earlier research by Suarez and the same colleagues traced the rapid decline of coast horned lizards in California to indirect impacts of invading Argentine ants. The invaders displaced indigenous ants, the lizard's favored food source. They are not a palatable substitute.

In related research published in several journals, the four scientists also showed that the loss of genetic diversity in introduced populations led to reduced aggression among the ants, allowing the formation of the supercolony in which queens and workers mix freely among separate nests. The invaders wipe out indigenous ants through sheer numbers.

### SOD found on UC Berkeley campus

A pathogen that has devastated wide swaths of California's oak trees has been discovered on the grounds of UC Berkeley, campus officials announced Oct. 31, 2001. The microbe responsible for sudden oak death (SOD) has infected three host species, including two California bay trees near the Faculty Glade. The infection has not been detected in any of the oak trees on campus, suggesting that it arrived recently.

Matteo Garbelotto of the UC Berkeley College of Natural Resources noticed the infections while walking through campus. Subsequent tests confirmed that the infections were caused by *Phytophthora ramorum* (see *California Agriculture*, January-February 2001). Garbelotto and UC Davis associate professor Dave Rizzo, in conjunction with the California Oak Mortality Task Force, were recently awarded a \$1 million grant from the San Francisco-based Gordon and Betty Moore Foundation, to study *P. ramorum*.

Approximately 50 campus groundskeepers, gardeners, arborists and horticulturists from UC Berkeley's Botanical Garden have received training to identify signs of SOD infection. They are canvassing the campus and gathering samples of suspicious vegetation. Disease management will include regular monitoring of the campus grounds and preventative treatments with fungicides. Areas surrounding the campus also will be surveyed through a joint effort between UC Berkeley and the Alameda County Agricultural Commission.

There are at least 10 known tree and plant species that are susceptible to the *P. ramorum* pathogen. The highly contagious microbe is a

brown algae related to the species responsible for Ireland's potato famine of the mid-1800s. Its ability to infect a wide array of plant life through soil, water and air has made it particularly difficult to control.

SOD was first noticed in Marin County in 1995 and has since felled tens of thousands of coast live oaks, black oaks and tan oaks in the state. Infections have recently been discovered along Crow Canyon Road in Alameda County and near Lake Madigan in Solano County.

### Mondavi gift benefits UC Davis wine and food sciences

On Sept. 19, 2001, Robert and Margrit Mondavi announced a personal gift of \$25 million to UC Davis to establish the Robert Mondavi Institute for Wine and Food Science. The gift will be combined with campus funds and other private contributions to create new state-of-the-art research and teaching facilities, to house the UC Davis College of Agriculture and Natural Resources departments of viticulture, enology, and food science and technology.

The institute will include an academic building of approximately 75,000 square feet for classrooms, laboratories, offices and meeting rooms. A 13,000-square-foot plant for food-processing, and a 36,000-square-foot building for a new campus teaching and research winery, also will be constructed within the proposed institute. Current plans call for the institute to be located on Old Davis Road; ground-breaking is expected in 2004.

The gift is the largest private contribution ever to UC Davis and represents one of the most generous single gifts from an individual donor in UC history. The Mondavis also donated \$10 million to name the UC Davis campus's Center for the Performing Arts, which is currently under construction.

— Compiled from U.C. and other news sources



Marc Dantzker

**Nonnative Argentine ant workers nurture scale insects in exchange for the sweet honeydew they excrete. By protecting scale, aphids and other homoptera from potential predators, Argentine ants promote populations increases among these agricultural pests.**



Tony Novelo/Axion

**A \$25 million gift from Robert and Margrit Mondavi will allow UC Davis to build a new facility combining viticulture, enology, and food science and technology. Graduate student Fiona Hutchinson pours peanuts into a machine that coats them with an edible covering made from whey proteins, a byproduct of cheese processing. The coating prolongs freshness while utilizing a dairy byproduct that has long been a waste disposal headache for cheese processors.**

Introduction

# California increases support for agricultural easements

**AS** urban development continues its creep into agricultural areas, California is stepping up efforts to protect farmland with conservation easements, which let landowners sell their nonagricultural development potential in perpetuity (in effect, forever). In 1996, the state established the California Farmland Conservancy Program (CFCP) to protect farmland by buying easements. In 2000, voters provided \$25 million for agricultural protection by approving Proposition 12, the \$2.1 billion parks bond. And in March 2002, voters could increase the total dramatically by approving Proposition 40, a \$2.6 billion parks bond that could provide an additional \$75 million to conserve agricultural land.

There are several other ways that farmland can be protected from residential or commercial development, such as outright purchase by conservation organizations or restrictive zoning ordinances. While conservation easements have traditionally targeted natural resource areas, over the past 20 years they have been increasingly used to protect agriculture in California and elsewhere.

"The trend at the state level is to expand funding for conservation easements," says UC Cooperative Extension public policy specialist Al Sokolow, noting that funding these easements at the local level is limited by tax restrictions and the scarcity of private donors.

### Working farms targeted

Originally called the Agricultural Land Stewardship Program, the CFCP is the only statewide program dedicated to protecting farmland with conservation easements. While two state agencies (the Coastal Conservancy and Wildlife Conservation Board) can also fund easements, they tend to focus on open space and wildlife habitat rather than keeping farmland in active production.

To date, the CFCP has awarded about \$16 million to fund 50 agricultural easements that protect more than 13,000 acres. An additional \$14 million in matching funds came from other sources, including landowner donations, the federal Farmland Protection Program and private foundations.

The CFCP currently receives \$1.5 million per year from the state general fund and about \$5 million per year from Proposition 12, which will continue to fund conservation easements through 2003, CFCP manager Charles Tyson says.

After that, the CFCP hopes that voters will approve Proposition 40. "A lot depends on the public's willingness to increase the frequency of funding," Tyson says.

Other funding mechanisms include private foundations, local bond issues and local taxes. For instance, Marin County allocates part of its property tax to Marin Agricultural Land Trust, and Sonoma County has a unique quarter-cent sales tax dedicated partly to protecting farmland around city edges. The Packard Foundation funds agricul-

Funding sources for agricultural easements have increased in recent years in California, although only a small portion of the state's farmland is protected using this technique. The 75-acre Oken property, foreground, was purchased by the Sonoma County Agricultural Preservation and Open Space District as a "community separator." Development rights were targeted strategically to create a greenbelt and prevent leapfrog development between Santa Rosa and Rohnert Park, background.

tural easements as does the Great Valley Center's Agricultural Transactions Program, which is initially awarding \$5.7 million for farmland protection in three counties (Merced, Stanislaus and Yolo).

### Strategic placement

Despite their growing popularity, easements still play a relatively small role in protecting farmland. "They're not significant in any way right now," says John Gamper of the California Farm Bureau Federation.

Statewide, there are only an estimated 120,000 acres in agricultural conservation easements, Sokolow says (see p. 15). Far more farmland enjoys shorter-term protection. More than 16 million acres are protected under the 1965 Williamson Act (which entails a 10-year commitment not to develop) and more than 400,000 acres are protected under the 1998 Farmland Security Zone program (which entails a 20-year commitment not to develop), Gamper says (see p. 13).

But numbers don't tell the whole story. The permanent protection afforded by agricultural easements is generally not needed for most of California's roughly 27 million acres of farmland. "Opportunities for turning rural land into residential land and other urban uses are generally confined to the fringes of expanding cities and other urban areas," Sokolow says. "Most California farmland is located far from the urbanizing fringes." Accordingly, the CFCP targets farmland that is at risk for development in the next 10 to 20 years.

Furthermore, well-planned agricultural easements can have a disproportionate effect that belies their small size. The CFCP targets farmland sites than can shield a much greater area from development. "Beyond a certain combined area, easements can be too expensive for urban infrastructure to leapfrog past," says the CFCP's Tyson. For instance, the nearly 2,000-acre set of easements bordering Cache Creek in Yolo County will probably curtail urban growth into prime farmland north of Woodland, he says.

Optimizing the size and placement of easements would be easier if planning were coordinated, farmland protection advocates say. That in turn depends on knowing the locations of existing easements, which is difficult because they are held by several dozen agencies and land trusts (see p. 9). To help local land-use planners choose the best sites, the state Farmland Mapping and Monitoring Program is working with the CALFED Bay-Delta Program

to map agricultural easements in the Sacramento-San Joaquin watershed. (This project receives funding from Proposition 13, the \$2 billion water bond passed in 2000.)

In addition, in 2002, Sokolow will work with American Farmland Trust (AFT) on national study of agricultural easement locations; AFT is a national farmland protection organization with a significant California presence.

### Overcoming barriers

Currently, the use of agricultural conservation easements in California is limited in part by farmers' lack of knowledge and understanding (see p. 21). "There's a fear factor that once you sign an easement, someone will tell you how to farm," Gamper says. In addition, some farmers are leery of signing away development potential in perpetuity, while others simply don't know that the option exists. The keys to increasing farmers' confidence include expanding the CFCP's outreach and establishing more local farmer-organized agricultural land trusts, Gamper says.

The CFCP's Tyson agrees, adding that the dearth of agricultural land trusts also limits the use of easements in California. Local governments need to have farmland conservation programs with funding to implement and monitor the easements — but only about 12 of the more than 110 land trusts in California focus exclusively or primarily on farmland.

"Cities and counties are underusing the CFCP program," Tyson says. "Large areas of the state are not served by agricultural land trusts," including Southern California and much of the agriculturally rich Central Valley (see pg. 22). For counties without them, "the American Farmland Trust can fill the void," Tyson says. "But there's less sense of local ownership. Local land trusts are good for farmer buy-in."

These issues notwithstanding, people on all sides of California agriculture support the concept of agricultural easements. "I don't think there's any other way to save farmland," says Jerry Meral, executive director of the Planning and Conservation League, a statewide nonprofit organization. "Lots of farmers out there would happily sell their development rights. We need more funding."  
— Robin Meadows

### Agricultural easement information sources

**American Farmland Trust**  
[www.farmland.org](http://www.farmland.org)

**California Farmland Conservancy Program**  
[www.consrv.ca.gov/drlp/CFCP/index.htm](http://www.consrv.ca.gov/drlp/CFCP/index.htm)

**Farmland Mapping and Monitoring Program**  
[www.consrv.ca.gov/dlrp/fmmp/fmmp\\_water\\_bond.htm](http://www.consrv.ca.gov/dlrp/fmmp/fmmp_water_bond.htm)

**Great Valley Center**  
[www.greatvalley.org](http://www.greatvalley.org)

**Planning and Conservation League/Proposition 40**  
[www.pcl.org/bonds/landconservation.html](http://www.pcl.org/bonds/landconservation.html)

**UC Agricultural Issues Center/Land-use and Farmland Conversion**  
<http://aic.ucdavis.edu/research1/land.html>

## Case study: Marin easements and local land-use planning



Depending on their location, agricultural easements can work closely with local government land-use planning to influence the pattern of urban growth in a community. In this map of Marin County, all 45 easements on 30,000 acres of dairy and ranch land — acquired by Marin Agricultural Land Trust (MALT) since its first transaction in 1983 — are located in Marin's rural agricultural corridor, an area identified for preservation in the county government's general plan during the late 1970s. The easements support the plan by helping block the expansion of urban growth from the eastern corridor, where the county's cities are situated along Highway 101, and by impeding the building of rural residences for nonfarmers on agricultural parcels. With several large blocks of ranchland currently covered, MALT's easement acquisitions are gradually filling in the county's agricultural area.

MALT's experience is not, however, the norm for California land trusts. As independent nonprofit organizations with grassroots origins, land trusts generally operate at an organizational and political distance from local governments; this independence can cause tension between a trust's easement acquisitions and county and city land-use policies.

### Editor's note:

In this special section, UC researchers explore a new application of an old land-preservation tool: conservation easements specifically utilized to protect California agriculture and farmland (see map at left).

The articles are based on a project begun in 1998, which consisted of three separate studies: (1) the motivations and experiences of farmland owners in three counties who sold easements; (2) the accomplishments, strategies, organization, funding and planning relationships of local easement programs; and (3) the prospects for the extensive use of easements in the Central Valley.

Semistructured, open-ended interviews were the principal data collection technique. Interviews were conducted with: 46 landowners in Marin, Sonoma and Yolo counties; the managers and other leaders of 34 local conservation organizations; and more than 110 community leaders in 11 Central Valley counties. The project also collected data such as budgets, program brochures and newsletters of conservation organizations.

The principal investigator is Alvin D. Sokolow, UC Cooperative Extension public policy specialist in the Department of Human and Community Development at UC Davis, and associate director for rural-urban issues of the UC Agricultural Issues Center. Research colleagues were Ellen Rilla, UCCE director in Marin County, and consultants Cathy Lemp and Robin Kozloff. Currently nearing completion, this research was supported by the Great Valley Center through a grant from the Land Conservation Office of the California Department of Conservation.

The UC Agricultural Issues Center published the first study report, *California Farmers and Conservation Easements: Motivations, Experiences and Perceptions in Three Counties*, in December 2000. Several related reports are forthcoming.



Agricultural easement programs.

# Saving agriculture or saving the environment?

Alvin D. Sokolow ■ Cathy Lemp

About 34 land trusts and open space districts in California have been pursuing agricultural conservation easements, which prevent development and keep land available for farming or ranching in perpetuity. This is a relatively new use of easements, which have traditionally targeted natural resources such as wilderness or wildlife habitat.

*California has 34 local conservation organizations, land trusts and open space districts that seek to protect farmland through conservation easements. In an examination of their mission statements and interviews with managers, we found variations in the extent to which the same easements protect both agricultural production and natural resources. Because they frequently protect farm operations that involve intense cultivation, cropland easements tend to be seen as incompatible with natural resource purposes such as riparian areas, habitat, wetlands and recreational trails.*

Using conservation easements to protect farmland from urbanization is a relatively new application of a technique that has been used in land preservation programs in the United States for about a century. Landowners who voluntarily sell easements or donate them for tax benefits, in effect give up development rights on their land in perpetuity while still retaining basic ownership (AFT 1997). Only in the past 20 years in California, and slightly longer in several other states, have state and local programs employed easements for the express purpose of keeping farmland in production. The more traditional uses have been for preserving land with natural resource or recreational values, such as riparian areas, wetlands, habitat and trails.

Thousands of agricultural acres — primarily grazing land — have been covered by environmentally oriented easements over the years. In part this is because farmland is a form of open space, a passive environmental amenity. But protecting agricultural production with easements intended to protect more specific natural resour-

ces, such as habitat and riparian areas, is more difficult for much of California's farmland, because orchards, vineyards, vegetable cultivation and other intensive crop production constitute a "working" rather than "natural" landscape. While sustainable agriculture offers considerable promise for minimizing the impacts of farming on natural resources, intensive crop production still generally involves chemical applications, the use of heavy machinery and other industrial-like activities.

The issue of compatibility between farming and natural resource protection is broad. We address it only in the context of conservation easements, by examining the agendas of local organizations with land conservation objectives. We identify 34 California organizations that emphasize farmland protection to varying degrees, and examine the mix of agricultural and other conservation purposes in their missions, drawing primarily from open-ended phone and personal interviews with program managers and from mission statements.

## Selecting 34 programs

The 34 California programs that fit our standards for having an interest in farmland protection include 30 non-profit land trusts and four open space districts. Land trusts are nonprofit, community organizations founded and run by volunteers and small staffs, while open space districts are local government entities governed by publicly elected boards (Vink 1999).

All four of the state's open space districts are included on this list. But the 30 land trusts are only a small portion of the more than 130 land trusts that operate throughout California, according to the 1998 directory of the national Land Trust Alliance (LTA) (1998). Among 20 different types of resource conservation purposes noted in the directory for individual California trusts (with multiple objectives cited in most cases), farmland/ranches ranked eighth in the frequency of mention. The top mentions were (1) watersheds/water quality, (2) rare species habitat, (3) scenic views, (4)



Since its founding in 1980, Marin Agricultural Land Trust (MALT) has put easements on more than 30,000 acres on 45 ranches and family farms. The former rangeland property, left, is located at the western edge of Novato's urban growth boundary.

wetlands, (5) river corridors, (6) trails and (7) forests/timberlands.

To select 30 farmland-oriented land trusts, we first identified 37 organizations that cited a farmland or ranch purpose in the LTA directory. Next, we added about 10 other trusts identified as having an agricultural orientation by other sources such as state and foundation programs, the American Farmland Trust and our own files. Finally, after speaking with program managers and reviewing mission statements, we narrowed the list down to 30 trusts. The final list does not include land trusts that acquired easements on grazing acres or other

farmland primarily for environmental, rather than agricultural purposes. The two essential selection criteria were (1) an expressed interest in the preservation of farmland as an agricultural resource and (2) the intention to use conservation easements.

For our purposes the farmland criterion encompasses both cropland and rangeland. The few California trusts that have forestry or growing of trees as their only "agricultural" activity were not included. Otherwise, we defined "farmland" and "agriculture" broadly. For example, one manager for a coastal land trust described the scope of his agricultural program as

TABLE 1. California conservation organizations with a farmland orientation

Principal county (other counties of operation)	Organization	Founded	Principal county (other counties of operation)	Organization	Founded
Alameda	South Livermore Valley Agricultural Land Trust	1994	San Benito	San Benito Agricultural Land Trust	1993
Amador (Calaveras, El Dorado)	Amador Land Trust	1990	San Bernardino	Southern California Agricultural Land Foundation	1988
Butte (Tehama)	Northern California Regional Land Trust	1990	San Luis Obispo	Land Conservancy of San Luis Obispo County	1984
Contra Costa	Agricultural Trust of Contra Costa County	1997	San Mateo (Santa Clara)	Peninsula Open Space Trust	1977
	Muir Heritage Land Trust	1988	San Mateo (Santa Clara, Santa Cruz)	Mid-Peninsula Regional Open Space District*	1972
El Dorado	American River Conservancy	1989	Santa Barbara	Land Trust for Santa Barbara County	1985
Fresno (Madera)	San Joaquin River Parkway and Conservation Trust	1988	Santa Clara	Land Trust of Santa Clara County	1997
Fresno (Madera, Mariposa, Tulare)	Sierra Foothill Conservancy	1995		Santa Clara County Open Space Authority*	1993
Marin	Marin Agricultural Land Trust	1980	Santa Cruz	Land Trust of Santa Cruz County	1978
	Marin County Open Space District*	1972	Solano	Solano County Farmland and Open Space Foundation	1986
Mendocino	Mendocino Land Trust	1976	Sonoma	Sonoma County Agricultural Preservation and Open Space District*	1990
	Anderson Valley Land Trust	1990		Bodega Land Trust	1992
Merced	Merced County Farmland and Open Space Trust	1993	Sonoma (Mendocino)	Sonoma County Land Trust	1976
Monterey	Monterey County Agricultural and Historical Land Conservancy	1984	Tulare	Sierra Los Tulares Land Trust	1993
Napa	Napa County Land Trust	1976	Ventura	Ventura County Agricultural Land Trust	1992
Sacramento	North Delta Conservancy	1991	Yolo	Yolo Land Trust	1988
	Sacramento Valley Open Space Conservancy	1990	Statewide	California Rangeland Trust	1998

\* Public agencies. All others are nonprofit organizations.

including, "all agricultural uses in accordance with sound and generally accepted agricultural management practices, such as breeding, raising, pasturing and grazing of livestock; production of food and fiber; breeding, raising and boarding horses, bees, poultry and other fowl; and planting, raising, harvesting other agricultural, horticultural and forestry crops."

In applying the second selection standard, use of easements, we emphasized intention rather than accomplishment. It was not necessary for an organization to have actually acquired specific easements. Rather, we deemed it sufficient to express an intention to acquire easements for farmland protection in the future. One justification for this liberal approach was recognition of how difficult it is for a new land trust to complete its first easement transaction, primarily due to funding limitations and landowner resistance (Faber 1999).

The trusts we identified are located in 29 of California's 58 counties (table 1). A few operate in more than one county, and the California Rangeland Trust has a statewide orientation with an emphasis on the Sierra foothills and Central Coast hillsides. (We left two Central Valley land trusts off our list that have potentially relevant activities: the Stanislaus Farmland Trust, which was formed in late 2000, shortly after the conclusion of our data collection, and the San Joaquin Open Space and Farmlands Trust, which has not been functioning for several years.)

Twenty-one of the 34 programs are concentrated in coastal areas, with 14 in the Bay Area alone (fig. 1). The Central Valley has nine and Sierra foothill counties have two. Least represented in relation to area and population, Southern California has only two organizations on our list, in Ventura and San Bernardino counties. No such programs are located in the major counties of Los Angeles, Orange, Riverside and San Diego.

### Two types of organizations

Both nonprofit organizations and public agencies are legally able to ac-

quire and hold conservation easements on private properties that restrict their future use. The key is their noncommercial and public interest character, which under federal law allows them to accept contributions of money or land interests as tax deductions. Nonprofit land trusts specifically qualify under section 501(c)(3) of the Internal Revenue Code.

But the California land trusts and public agencies (primarily open space districts) have distinctly different forms and operational procedures. Land trusts are independent, nongovernmental entities with no formal accountability to the community or its political bodies. Volunteer boards of directors, who fill their own vacancies, govern them and a number have small staffs and membership or donor rolls. Because of their grassroots origins,

flexibility, citizen participation and conservation credentials, land trusts are an attractive alternative to local government as the major mechanism for acquiring and holding easements (Daniels and Bowers 1997; Vink 1999).

No California county and city governments directly operate agricultural easement programs, although they frequently require the donation of easements as mitigation for approving development projects. The open space districts and several regional conservancies organized by state government are the only public agencies in California with active easement programs. Unlike the nonprofits, the districts are accountable to their communities via separately elected governing boards or are extensions of county government and the elected board of supervisors.



Fig. 1. California land trusts and open space districts with agricultural programs. Counties shown have one program, unless otherwise indicated by a number in parentheses.

Source: Al Sokolow, Cathy Lemp and Jeff Woled.

**TABLE 2. Local easement programs by degree of agricultural interest**

**Exclusively or primarily agricultural**

Agricultural Trust of Contra Costa County  
 Amador Land Trust  
 Marin Agricultural Land Trust  
 Merced County Farmland and Open Space Trust  
 Monterey County Agricultural and Historical Land Conservancy  
 San Benito Agricultural Land Trust  
 Southern California Agricultural Land Foundation  
 South Livermore Valley Agricultural Land Trust  
 Ventura County Agricultural Land Trust  
 Yolo Land Trust  
 California Rangeland Trust

**Equal emphasis to agricultural/other resources**

Anderson Valley Land Trust  
 Bodega Land Trust  
 Land Conservancy of San Luis Obispo County  
 Land Trust for Santa Barbara County  
 Land Trust of Santa Clara County  
 Land Trust of Santa Cruz County  
 Mendocino Land Trust  
 Muir Heritage Land Trust  
 Napa County Land Trust  
 North Delta Conservancy  
 Northern California Regional Land Trust  
 Peninsula Open Space Trust  
 San Joaquin River Parkway and Conservation Trust  
 Sierra Foothill Conservancy  
 Solano County Farmland and Open Space Foundation  
 Sonoma County Land Trust  
 Mid-Peninsula Regional Open Space District\*  
 Sonoma County Agricultural Preservation and Open Space District\*

**Primarily other resources with significant agricultural interest**

American River Conservancy  
 Sacramento Valley Open Space Conservancy  
 Sierra Los Tulares Land Trust  
 Marin County Open Space District\*  
 Santa Clara County Open Space Authority\*

\* Open space districts: all others are nonprofit land trusts.

**Agricultural emphasis**

While each of the 34 organizations identifies farmland protection as an important objective, the degree of emphasis often varies. The names of land trusts and open space districts suggest this variation; the terms “agriculture,” “farmland” or “rangeland” are found in only 11 names, sometimes in combination with “open space” or other designations. Based on our review of mission statements and interview comments, we sorted the 34 organiza-



Phil Schermeister

**In 1999, Napa County Land Trust made farmlands such as vineyards a top priority, in part to support a county-supported agricultural preserve on the Napa Valley floor.**

tions into three categories, according to differing agricultural emphases (table 2).

Only a third of the 34 organizations are unwavering in their exclusive or primary focus on farmland. We included some trusts that focus on grazing (ranch) cropland properties and others that are primarily interested in cropland. The California Rangeland Trust and Amador Land Trust concentrate on foothill ranch land, while the Monterey, South Livermore Valley and Yolo trusts focus almost entirely on orchards, vineyards, vegetable-growing parcels and other croplands.

In recent years, some organizations with broad or multiple conservation objectives have begun to emphasize farmland protection, perhaps motivated by new funding opportunities for farmland easements created by state government and other agencies. Some land trusts have also reassessed their conservation objectives to reflect community concern about farmland loss and increased landowner interest in easements.

Two such programs are the Napa County Land Trust and the Mid-Peninsula Regional Open Space District (south of San Francisco), neither of which emphasized farmland protection in their original missions. Following a planning exercise conducted by its board, the Napa trust in 1999 established agricultural lands as

its top conservation priority, partly to support the agricultural preserve created for the Napa Valley floor by county government policy. As a result of an advisory voter referendum and the encouragement of other conservation groups, in 2000 the Mid-Peninsula district extended its boundaries to an area of prime farmland along the San Mateo coast.

**Agriculture-resources compatibility**

Interviewees frequently commented on the connection between protecting agricultural activity and preserving natural resources such as habitat, wetlands and scenic views. The same easements, some said, could accommodate both purposes. Others, however, discussed serious limitations, citing conflicts between cultivation and other aspects of commercial agricultural production, and the preservation of natural resources.

At its most general level, the argument for compatibility simply views farmland as additional open space, a landscape free from human congestion and an antidote to urbanization. Farmland is the only or principal form of nonurban land in many California communities and regions. “If you are not working with ranchers and farmers, you are not going to get any open space,” noted the manager of a Bay Area program. Emphasizing the open

## Williamson Act also protects farmland

space values of agricultural easements appeals to urban residents and helps build communitywide support. "We realized that in order to appeal to more people, we have to recognize that agricultural land is also open space under private ownership," the Bay Area manager said.

It is a step further to focus on the compatibility of agricultural activity with specific plant and animal resources and landscape features (Anderson 1995). According to some managers of programs that concentrate on ranch land, cattle grazing has beneficial effects on local habitats. They note that controlled grazing helps to cut back nonnative grasses and reduce the possibility of wildfires.

One land trust manager who works with ranchers said:

"Our primary objective is to provide alternative ways to address the economic viability of rangeland agriculture and to conserve the natural balance of the ecosystem. We see the two as being intertwined. And so we try to provide services and education to ranchers about how they can integrate their economic needs with the environmental and ecological needs of their rangeland. I think there's been a shift in the way the cattle industry looks at these issues. Many people are beginning to see that they've got assets on their ranch that are not necessarily related to the commodity that they produce, whether that's open space, or recreational opportunities or watershed values" (April 16, 1999).

There is far less compatibility for farm operations that involve intensive cultivation and chemical applications, including orchards, vineyards and vegetables and parcels devoted to confined animal production (Daniels and Bowers 1997). While the potential for protecting natural resource lands is ever present in the easement priorities of organizations that focus on cropland, this clearly takes a back seat to their emphasis on protecting commercial agriculture. The Yolo Land Trust makes a sharp distinction between two types of easements: "A farmland con-

California's Williamson Act is another program that compensates landowners for keeping their properties in agricultural use. For more than 30 years, the program has allowed farmland owners to enter into contracts with county or city governments to lower their property taxes, in exchange for giving up the option to develop the land for urban uses in 10, 20 or more years. The contracts are renewed automatically every year unless either party seeks nonrenewal, or a cancellation is approved under rigorous standards.

Easements and Williamson Act contracts are similar in that both protect farmland from urbanization, rely on voluntary landowner action, run for long periods of time and compensate landowners. The California Department of Conservation's Division of Land Resource Protection administers both.

There are, however, several major differences. With their perpetual restrictions on development, easements last for generations rather than decades, making the landowner's decision to sell an easement by nature more difficult. At the same time, easements generate considerably greater immediate economic benefits for landowners, typically several thousand dollars per acre in purchase price, as compared to the more modest tax benefits available to Williamson Act contract holders.

In a different fiscal area, Williamson Act contracts reduce property tax revenues to local governments, although they are partially compensated by state grants (subventions). Placing an easement on a farm, on the other hand, has little immediate impact on the property taxes paid on the parcel, although the county assessor may eventually reduce the land's assessed value due to the elimination of speculative or development value. Finally, many more California agricultural acres are covered by Williamson Act contracts than are under easement, almost 16 million versus an estimated 120,000 acres, respectively.

As of the beginning of 2000, the basic Williamson Act program had enrolled 15.4 million acres (about one-third on cropland and two-thirds on grazing land), and 51 counties actively offered contracts. An additional 400,000 acres in 17 counties were enrolled under Farmland Security Zone (or "super" Williamson Act) contracts, a new option for landowners created by state legislation in 1998. This program provides a bonus 35% in property tax reductions beyond the basic benefit, but eligibility is generally limited to cropland and contracts run for 20 years or more. For the Williamson Act program as a whole, the state annually spends about \$36 million to compensate participating counties (and a few cities) for a portion of their lost property taxes.

— A.S.

servation easement contains restrictions to keep the land in agriculture. A habitat conservation easement is written to protect the habitat value of the land" ([www.virtual-markets.net/go/yololand](http://www.virtual-markets.net/go/yololand)).

By these standards, intensive farming conflicts with efforts to preserve highly sensitive habitat, such as vernal pools, other wetlands and riparian corridors — conditions that also restrict cattle grazing in particular areas. A related but separate issue is the possibility of opening easement-protected properties to public access. Most farmers interested in selling an easement explicitly reject such use, citing liability problems and interference with farm operations. This severely limits the use of easement-protected farmland for trails and other recreational purposes, highly desired open space amenities for urban populations.

Despite these incompatibilities, program managers we interviewed identified a number of examples of easements created primarily for the protection of agricultural operations, including crop production, that also serve habitat preservation purposes. Some cover sizable parcels that allow for the geographic separation of the different uses. For example, the Mendocino Land Trust acquired a 430-acre easement with 60% devoted to agriculture and 40% in preserved oak woodlands. Several easements

held by the Yolo Land Trust are used mainly for crop production but are traversed by streams with riparian corridors closed to cultivation.

Some interviewees suggested that easements are not the best option for preserving sensitive habitat and providing public recreation, because of the complications generated by private ownership. The better approach, instead, would be outright purchase and ownership by public or nonprofit agencies, simplifying management and perhaps allowing low-intensity agricultural operations on a lease basis. One land trust manager noted that government agencies and foundations that fund environmental easements usually prefer to support fee purchases, especially in areas removed from urban pressures where easement prices per acre tend to be relatively low. Indeed, several organizations in our study with significant nonagricultural goals both hold easements and own and manage large parcels as nature preserves or recreational sites.

### Broad conservation agendas

Thirty-four local conservation organizations in California seek to protect farmland via the acquisition of conservation easements. About a third focus exclusively or primarily on farmland, while the greater number fit this objective into broader conservation agendas that include the preservation of lands

with natural resource values. The degree to which programs seek individual easements to achieve both farmland and resource protection varies. The objectives are compatible or incompatible, depending on the agricultural commodities that are grown, cultivation practices and the natural resources to be protected. The smaller number of programs expressly focused on farmland, especially those concerned with protecting cropland, tend to make a sharp distinction between different conservation purposes, but on occasion they also recognize secondary resource values in some of their agricultural easements.

Concerned primarily with identifying California's agricultural conservation programs and their missions, we did not thoroughly examine issues of compatibility. A broader research approach is needed to for this purpose, one that examines in detail agricultural practices and impacts in different environmental settings and the application of sustainable agricultural techniques.

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*A.D. Sokolow is Public Policy Specialist, Human and Community Development, UC Davis; and C. Lemp is Program Evaluation Consultant, based in Sonora.*

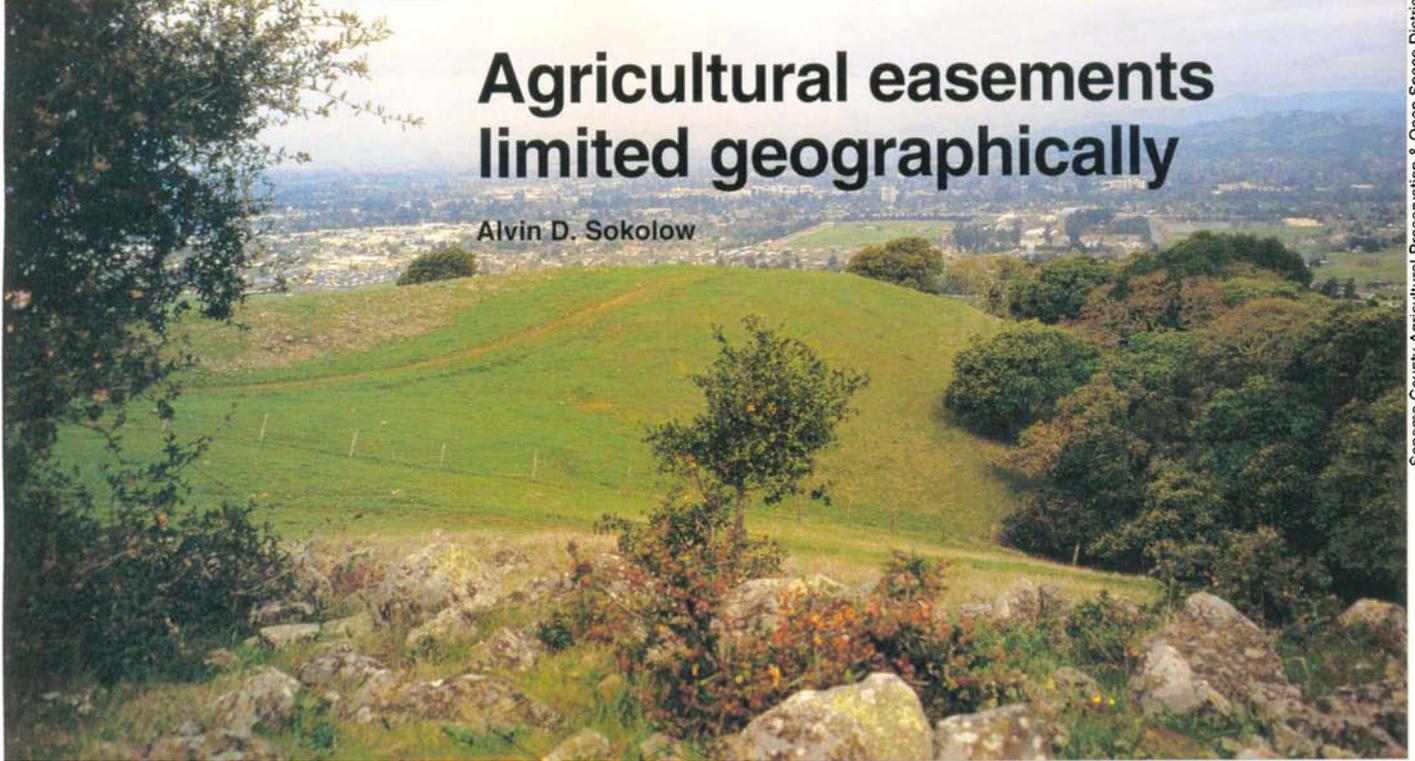
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Sonoma County Agricultural Preservation & Open Space District



**Wetlands and vernal pools of the Laguna de Santa Rosa area are a high priority for natural resource protection in Sonoma County. The line between natural areas and farmland is often blurry; while some easements cover both, this is not always possible because of incompatible conservation purposes.**



Sonoma County Agricultural Preservation & Open Space District

# Agricultural easements limited geographically

Alvin D. Sokolow

About one-third of the state's land trusts and open space districts that focus primarily on protecting farmland hold 90% of the agricultural easement acreage in California. Most acreage is concentrated on the coast and in the Bay Area. In Sonoma County, the Santa Rosa Plain can be seen from Taylor Mountain.

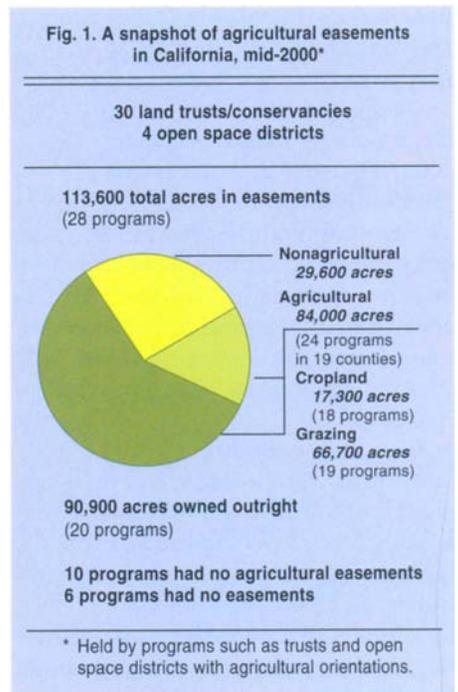
*A review of conservation programs in the state shows that agricultural easements are concentrated in central coastal counties. Many of these counties, such as Marin and Sonoma, are not top agricultural regions, while some of the state's most productive agricultural counties have no easement programs at all. To date, there are approximately 120,000 California farmland acres in easements, nearly 80% of them grazing land and the rest in crops. Our review shows that state coastal conservation programs and sentiments among local populations are major reasons why easements are plentiful in some counties and not in others.*

Just a few local and regional conservation programs have secured the vast majority of farmland acres covered by agricultural easements in California. Among the 34 land trusts and districts identified by our research as having significant farmland protection objectives, 12 held about 90% of all acres under agricultural easements throughout the state as of mid-2000.

Why are some farmland protection programs more successful than others in easement acquisitions? And what do these findings suggest for the future of easements as a farmland protection technique in California? After reviewing statewide patterns and the achievements of the most active programs, we examine the revenue and organization and other factors involved in the development of a successful agricultural easement acquisition program.

## Statewide easement patterns

Agricultural easements are a compensatory and nonregulatory technique for protecting farmland from urbanization, through the purchase of development rights (or their donation) from landowners. Local conservation



organizations, land trusts or public agencies acquire and hold the easements and manage them over time (American Farmland Trust 1997; Daniels and Bowers 1997).

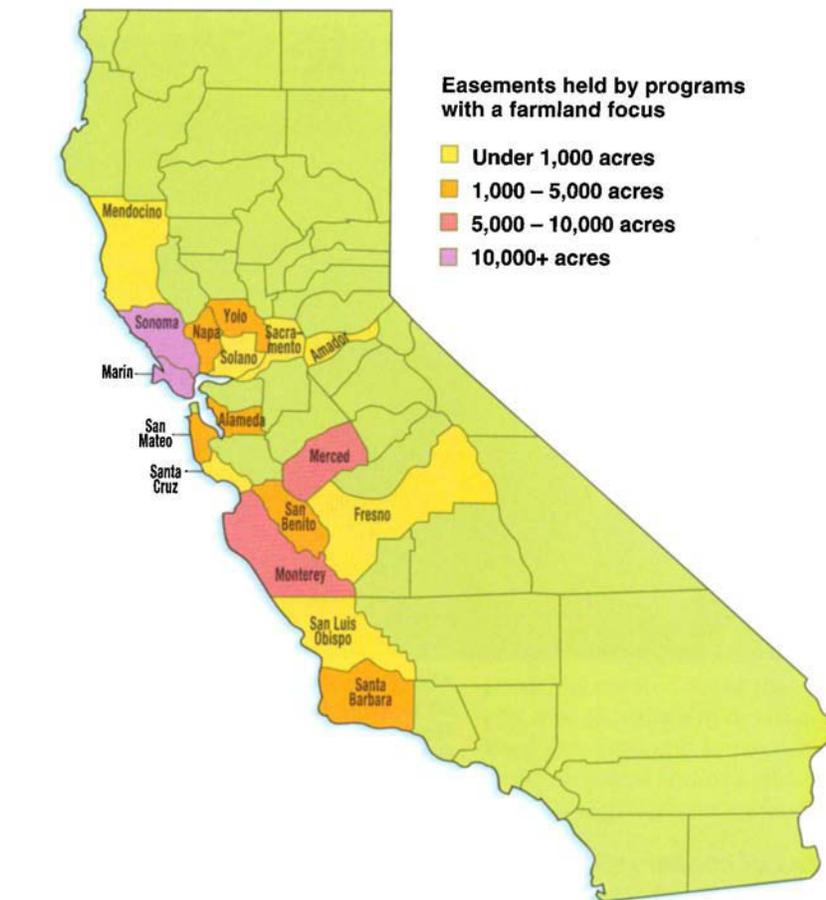
Based on information provided by 34 identified programs with farmland protection objectives (see table 1, p. 10),

we estimate that California now has about 120,000 acres in agricultural easements. This projection updates an earlier estimate of about 84,000 acres statewide in mid-2000, based on individual reports from program managers at that time (see fig. 1). The exact number is a moving target, since the most active programs have been picking up easements at a rapid pace. Even as program managers provided the data on easements completed in mid-2000, they also reported in-the-works transactions with landowners to acquire another 21,000 acres.

Not included in these estimates were other agricultural acres protected by easements primarily for environmental purposes, such as wetlands, habitat and riparian corridors (see p. 9). Anecdotal evidence suggests that there are many thousands of such acres throughout the state, with easements acquired and held by local land trusts and open space districts, national conservation organizations such as The Nature Conservancy, and state and federal wildlife agencies (Bay Area Open Space Council 1999).

Of the 34 organizations, only 24 had acquired agricultural easements by 2000, reflecting that many new programs are still in the formative stage. The programs studied held 29,600 acres in nonagricultural easements and owned outright another 90,900 acres in natural resources and recreational areas, indicating that many programs pursue multiple conservation goals.

Only about one-fifth (20.6%) of the total agricultural easement acres were cropland; four-fifths (79.4%) were grazing land. By comparison, cropland and grazing acres represent much larger and smaller shares, respectively, of California's total farmland base — about one-third and two-thirds of the total (DOC 2000). One explanation for the prevalence of grazing acres in easement programs is the relatively large size of cattle ranches and the preference of some programs to put an easement on one large ranch in a single transaction, rather than undertaking the more difficult task of seeking mul-



**Fig. 2. Easement acres on California farmland by county, as of mid-2000. Includes about 82,000 acres in 17 counties (easements held by 18 land trusts and three open space districts). Does not include 1,800 acres in two other counties held by two trusts operating in multiple counties.**

multiple easements from numerous owners of smaller cropland farms.

Farms under easement are an infinitesimal share of California's total 27 million agricultural acres. These are located in only 19 of the state's 58 counties (fig. 2). They are concentrated in eight coastal counties from Mendocino to the north and Santa Barbara to the south, and in three adjacent Bay Area counties (Napa, Solano and Alameda). The coastal counties alone contain more than 80% of all easement acres. Three Central Valley counties (Yolo, Sacramento and Fresno) are also represented in the easement ranks.

This geographical pattern is also notable for the regions that lacked any agricultural easement activity in 2000: the southern and northern thirds of the state. Just as striking is the absence of many important agricultural coun-

ties. Among the 11 counties that lead the state in agricultural production value, each with at least \$1 billion in market receipts in 1999, only three (Fresno, Monterey and Merced) contained agricultural easements as of mid-2000 (CDFA 2000). Counties with farm market values of \$1 billion or more in 1999 that did not have agriculture easements were Imperial, Kern, Riverside, San Diego, San Joaquin, Stanislaus, Tulare and Ventura. On the other hand, Sonoma and Marin — the top counties in agricultural easement acres — ranked 16th and 44th, respectively, in farm market value among all California counties.

The pattern of varying easement activity among top agricultural counties can be explained, in part, by underlying differences in the conservation sentiments of local populations. For

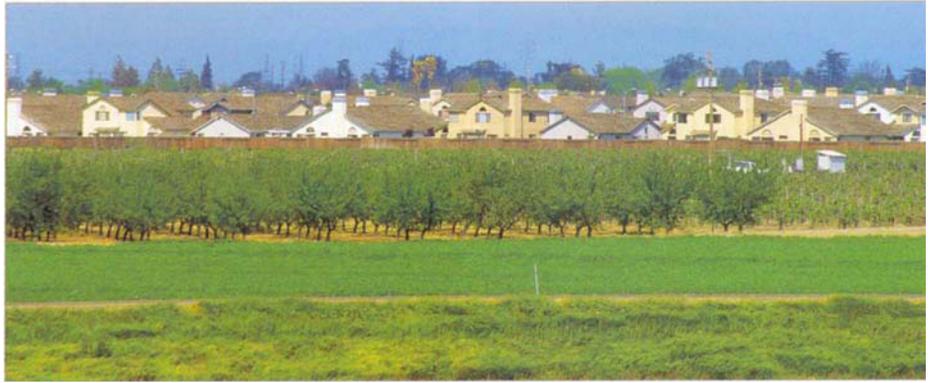
example, Central Coast voters have shown higher levels of support for environmental measures on statewide ballots than voters in inland and southern counties (Sokolow 1998). As a result, citizen coalitions with land conservation or other environmental agendas are more likely to form in Central Coast communities, which may explain the relatively larger number of land trusts in these areas.

Yet not all Central Coast counties have active agricultural easement programs. Santa Cruz, Santa Clara and Ventura counties, for example, had recorded no agricultural easements or far fewer than nearby areas as of mid-2000. In interviews, conservation organization managers cited as reasons the higher costs of acquiring easements on farmland in some of these locations and the greater interest of local land trusts in conserving environmental lands and engaging in educational and other activities.

### The largest programs

Each of a dozen programs — 11 land trusts and one open space district — had acquired easements on 1,000 or more agricultural acres as of 2000. Their collective holdings totaled about 79,000 acres, 94% of the state total.

Among the 12 programs are six coastal programs, three in adjacent counties, two in the Central Valley and one statewide program (California Rangeland Trust) (fig. 3). The two largest programs combined held more than 46,000 farmland easement acres, or slightly more than half of the statewide total. Serving adjacent North Bay counties, Marin Agricultural Land Trust (MALT) and the Sonoma County Agricultural Preservation and Open Space District have been the two most active farmland easement programs in California (and among the most active in the nation) since the mid-1990s. More than 150 separate transactions were represented by these easements. In some cases, the number of separate transactions is a better measure than total acres of the organization's achievements, since each transaction is the result of a complex process



Only three of California's 11 counties with agricultural receipts of \$1 billion or more have farmland protected by agricultural conservation easements. In the Central Valley's San Joaquin County, which does not currently have an active land trust or open space district, farmland in Manteca, above, is being pressed by suburban sprawl.

that includes extensive landowner negotiations.

Most of the 12 programs exclusively or primarily hold easements on grazing land. Only the Monterey, Yolo and South Livermore Valley land trusts are exclusively or primarily involved in acquiring and holding easements on cropland, although several others with large holdings in acres overall also have significant cropland acres. The crops grown on easement-protected land include artichokes, strawberries, vegetables and grapes in coastal counties, and field and orchard crops in the Central Valley.

### Program success stories

The first agricultural easement in California was acquired by MALT in 1983. In fact, most of the easements accumulated by all agricultural programs by 2000 had been acquired only in the previous 5 or 6 years, since the early and mid-1990s. The 12 leading programs quickly established successful records. Other programs in our sample had accomplished far less or had yet to acquire their first agricultural easements, although some had placed significant amounts of nonagricultural land under environmental easements.

Each of the leading programs followed a unique path, but they have several underlying factors in common. The most critical element seems to have been early access to funds or other acquisition resources, in part a result of fortunate timing, location and community support. But success was

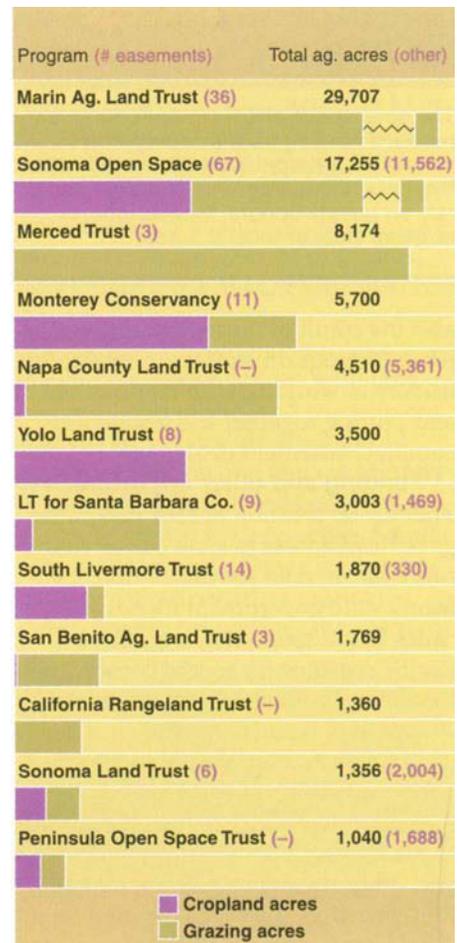
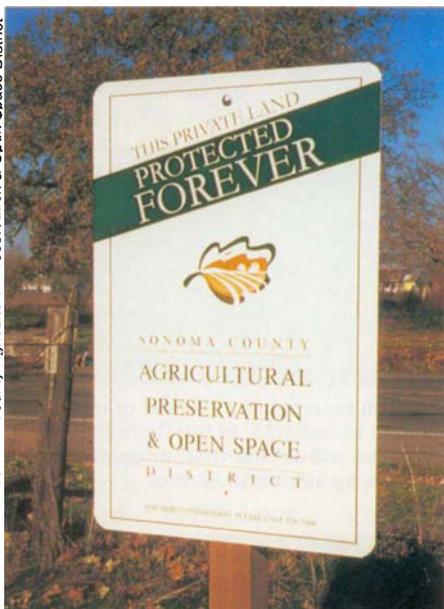


Fig. 3. Leading agricultural easement programs in California, by acres. Programs with 1000+ acres each, ranked by agricultural acreage as of mid-2000.

Note: Sonoma Open Space = Sonoma County Agricultural Preservation and Open Space District; Merced Trust = Merced County Farmland and Open Space Trust; Monterey Conservancy = Monterey County Agricultural and Historical Land Conservancy; South Livermore Trust = South Livermore Valley Agricultural Land Trust.



**The open space district in Sonoma County receives funding from a countywide 0.25-cent sales tax, approved by voters in 1990. Most easement programs, however, must rely on private donors, foundations, or targeted state or federal funds.**

also the result of the skill and persistence of program staff and community leaders in working with landowners and putting together the resources to complete easement deals.

**Funding and other opportunities.**

The coastal location of four programs gave them access to state conservation funds earmarked for this region. California state government for several decades has targeted the long, narrow Pacific coastline for special conservation measures, starting with the creation in 1972 of the Coastal Commission, a land-use regulatory agency. A more beneficial action for landowners was the formation in 1976, by state legislation, of the Coastal Conservancy, which was given the nonregulatory task of preserving coastal areas through landowner compensation. State appropriations began to flow to local agencies after the 1988 passage of Proposition 70. This bond issue generated \$776 million for state and local land-conservation programs, mainly to acquire and improve parks and wildlife habitat. A small portion of the total, some allocated through the Coastal Conservancy, eventually was used to acquire easements on farm-

land that had other resource values (Coastal Conservancy 1989).

At least four of the successful programs benefited from these actions shortly after their formations. MALT, the Sonoma Land Trust (a separate nonprofit entity from the open space district) and the Monterey County Agricultural and Historical Land Conservancy, either independently or with their county governments, each received a \$1 million grant from the Coastal Conservancy in the mid-1980s. All three land trusts, together with the Peninsula Open Space Trust (south of San Francisco), a few years later obtained Proposition 70 funds for easement activities.

Two land trusts among the 12 leading agricultural programs have prospered from a different type of funding stimulus — local government mitigation of farmland loss, which requires urban development projects to pay for easements on comparable farmland. The Yolo Land Trust received its initial easements as the result of a mitigation ordinance passed by the city of Davis in 1995, the first such municipal action in California. The South Livermore Valley Agricultural Land Trust was formed and acquired many of its easements as the result of litigation, in which the city of Livermore successfully challenged a large residential project. Another trust that has concentrated on environmental easements, the Solano County Farmland and Open Space Foundation, also benefits from a mitigation arrangement as a result of litigation involving the city of Fairfield.

The Sonoma County Agricultural Preservation and Open Space District is in a different funding category because of its countywide 0.25-cent sales tax, approved by voters in 1990. The district, which relies exclusively on this 20-year revenue source for its operations and purchases, was the only California entity with a dedicated tax for acquiring farmland easements until November 2000, when voters in Davis approved a parcel tax to fund a land conservation program that includes easements.

Several of the other leading programs depended largely or primarily on landowner donations of easements, including Napa County Land Trust, Land Trust for Santa Barbara County, California Rangeland Trust and Sonoma Land Trust. All four have broader open space and conservation interests than just farmland protection, and their donated easements have come primarily from owners of large ranches who are generally motivated by the tax benefits or preservation of the environmental qualities of their properties.

Beyond their formative years, most of the successful programs have been able to tap a variety of sources to fund easement acquisitions (table 1). External sources and landowner donations of easements were most frequently used, particularly grants from state and federal governments and from private foundations. Internal sources, including both private funds and public revenues, were less widely used. California's strict rules for funding local government programs, especially the restricted property tax and two-thirds voter approval requirements for new or increased taxes, severely limit the ability of communities to support easement programs with local taxes.

**Entrepreneurship.** The less tan-

**TABLE 1: Major funding sources for easement acquisitions by 12 largest programs, as of 2000\***

Funding source (used by number of programs)
<b>External</b>
State Farmland Conservancy/ Agricultural Land Stewardship Program (5)
State Coastal Conservancy/ Proposition 70 (1988 bond issue) (5)
Federal Farmland Protection Program (4)
Private foundations (7)
<b>Landowners</b>
Easement donations (6)
<b>Community</b>
Sales tax (1)
County property tax support (2)
Development mitigation (3)
Local donations and gifts (3)
Revenue from properties (1)

\* Source: Phone interviews with program managers in 2000.



**Obstacles to more widespread use of agricultural easements include lack of local interest and limited funds. Many landowners are reluctant to relinquish the right to sell land for development some time in the future. These luxury homes are under construction in Novato, Marin County.**

gible elements of program entrepreneurship were also important to the success of the leading programs. Even with early funding opportunities, the leaders of the better-funded programs had to apply skill, focus and persistence, and to work hard over long periods of time, to get their organizations going. To build a record of acquisitions, they had to look for funds from competitive sources and/or seek landowner donations. Program leaders had to match funding with landowner interests, a process that involved a time-sensitive juggling of several inter-related factors: dealing with foundations and state government as funding sources, selecting or seeking out appropriate parcel candidates according to the trust's priorities, matching available funding with available landowners and negotiating with landowners.

Each easement transaction is process unto itself. One land trust manager estimated that the average direct cost of completing a transaction was \$15,000 in staff time and other expenses. Another estimated that putting an easement together required several hundred hours in staff time.

As much as funding or landowner donations, the critical resources in this process were the personal skill, focus and persistence of program leaders. The successful programs generally

have small professional staffs, but they also rely extensively on the work of volunteer boards, which typically include members with expertise in law, resource management, agriculture, finance, land appraisal and other relevant areas. Land trusts with boards composed substantially of farmland owners, such as the Yolo and Merced trusts, are especially equipped to use board members' local knowledge and personal contacts in persuasive discussions with other farmers and ranchers who own desirable parcels. Explaining this strategy, one land trust manager noted: "The [founders of the trust] knew that they couldn't be an urban group going out to the farmers and telling them how to change their land. The message had to come from colleagues — other farmers and ranchers in the community. . . . If you want to be effective in agricultural preservation, you need to get along with the people of the land. . . and that includes the (local) Farm Bureau" (interview, July 7, 1999).

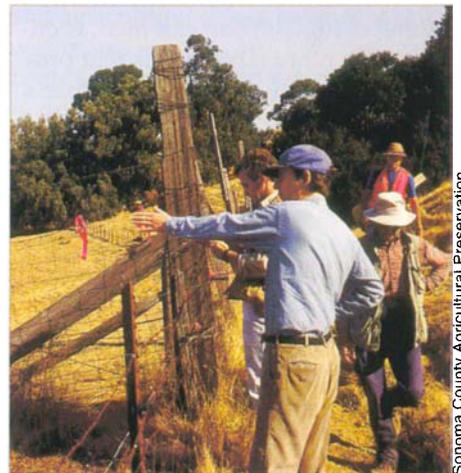
### **Obstacles to widespread use**

Despite recent achievements of the leading programs and general popularity of this nonregulatory technique for preserving farmland, agricultural easement programs have not yet caught on in a substantial way in most of California's agricultural counties.

The limited progress so far may be understandable, considering the still-new status of the technique as a farmland protection tool. In time, with greater familiarity and acceptance in agricultural and other community circles, and fueled by the achievements of the first active programs, there could be a rapid expansion in the number and geographical extent of programs and acres covered (Great Valley Center 1998).

This is not a certain scenario in the near future, however. There are at least three major obstacles to more widespread use of the agricultural easement technique.

**Difficulty of organizing.** It takes a high degree of citizen interest or local government support to form a land trust or open space district, qualities not currently present in many agricultural areas. Local and regional organizations run the easement programs, rather than more distant state government and other outside agencies, because successful easement transactions depend on close relations with landowners. Most of the land trusts in our study were created through the grassroots efforts of a few community leaders or environmental activists, organizing effectively to pursue shared conservation goals. Other land trusts and open space districts originated more directly through local govern-



**The Weston family sold an easement on their 1,160-acre ranch north of Santa Rosa, which will be preserved for natural resources and cattle ranching.**



**Hafey Ranch is one of the few remaining livestock ranches in Knight's Valley, a premier vineyard region of Sonoma County near the Napa County border. A few early transactions by landowners respected in the local farming community can pave the way for future deals.**

ment action, including voter approval.

**Lack of revenue stream.** Few of the established programs in California enjoy a steady revenue stream for building large agricultural easement portfolios. Programs with substantial acquisitions have relied largely on fluctuating and opportunistic revenue sources, primarily state government funds and foundation grants. They generally lack the certainty that an ongoing, dedicated local tax source could provide. As a result, most programs acquire easements in fits and starts, limiting their ability to plan and work quickly with interested landowners.

**Landowner reluctance.** Landowners cannot be compelled to enter into an easement transaction by government regulation or eminent domain; selling or donating an easement is entirely voluntary. This means that programs must rely on each landowner's understanding of the technique and personal estimate of benefits and costs. For many landowners, easements are a foreign or confusing concept. They offer the unwelcome prospect of having less control over their land and create uncertainties about the long-term consequences for immediate heirs and later generations of owners. Landowners located near rapidly urbanizing areas are especially reluctant to consider the easement option, as they believe that they will be able to prosper by selling their parcels for residential or commercial development sometime in the future. Finally, even with a supply

of willing landowners, there is the challenge of fitting the available properties into a program's criteria for location, agricultural quality and easement price. Nonetheless, the successful programs demonstrate that a few early transactions with landowners respected in the local farm community can break the ice for subsequent deals (Rilla and Sokolow 2000).

### Future of easements

Primarily because they are nonregulatory and voluntary, easements on farmland increasingly appeal to landowners and communities attempting to protect open space and agriculture. With about 120,000 farm acres covered statewide, agricultural easements have become an important farmland protection tool in California in less than two decades. A small number of local land trusts and open space districts, assisted by funding opportunities and entrepreneurship, have established successful programs.

Yet the active programs operate in only a minority of California's major agricultural counties. Many of these areas lack easement programs because of the absence of citizen interest and mobilization combined with local government inaction. Most established programs also are limited in their easement acquisitions, largely because of unsteady revenues, limited entrepreneurship and reluctant landowners.

Undoubtedly, the few successful

programs will continue to grow and expand their easement holdings. But expanding agricultural easements to major agricultural regions is the key to making optimal use of the technique in California.

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*A.D. Sokolow is Public Policy Specialist, Human and Community Development, UC Davis.*

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# Landowners, while pleased with agricultural easements, suggest improvements

Ellen Rilla

*We extensively interviewed 46 landowners in two northern Bay Area counties and nearby Yolo County to assess their satisfaction with agricultural conservation easements. The landowners in most cases were enthusiastic sellers of the easements; their motivations included cash, keeping land in the family and conservation. They reported generally satisfactory experiences with the easement programs. To a lesser degree they expressed concerns about certain aspects of the easement process, especially negotiations and monitoring, and suggested ways that easement programs can improve their relationships with landowners.*



Marin Agricultural Land Trust

**In a survey, the main reasons landowners cited for selling easements were cash, maintaining family ownership and conservation. In Marin County, Marin Agricultural Land Trust's purchase of a 400-acre easement allowed the Ielmorini family to buy this dairy, which they had leased for 6 years.**

For a landowner, the decision to sell or donate an agricultural conservation easement is a momentous one that is not made lightly or quickly. Negotiated voluntarily with a nonprofit or public land-trust agency, conservation easements restrict the use of a particular parcel; the landowner can continue farming after the easement is purchased, but the land can never be subdivided or developed. Land in easements can be bought or sold, but the restrictions remain in perpetuity. The decision to sell, then, depends on the landowner's willingness to forego the profitable option of selling the land for urban development in return for more modest economic gains and other benefits. While cash or tax advantages provide immediate benefits to the present landowner, future generations and owners carry the costs in terms of restrictions and limited opportunities.

Based on extensive interviews with 46 owners of easement-restricted farms in three counties (Rilla and Sokolow 2000), we have examined landowner motivations for selling easements and their experiences with local programs that acquired the easements (Sherman et al. 1998; Maynard et al. 1998; Elconin and Luzadis 1997). The landowners in most cases were enthusiastic sellers of the easements. Their main motivations were cash, family ownership and conservation, and they reported generally satisfactory experiences with the easement programs. To a lesser degree they expressed concerns about certain aspects of the process, especially negotiations and monitoring, and suggested ways that easement programs can improve their relationships with landowners.

Most of the landowners interviewed are located in two North Bay

counties, the region that contains most of California's farmland easement acres and easement programs. Given the unique conservation, landscape and agricultural characteristics of this region, it's not yet clear what the prospects are for easement programs statewide and in the agriculturally rich Central Valley, where they are much less well-established (see p. 22).

## Landowners surveyed

The landowners who participated in this study are involved in three of the most active agricultural easement programs in California. The programs are countywide in scope. The Marin Agricultural Land Trust (formed in 1980) and Yolo Land Trust (formed in 1988) are private, nonprofit organizations, chartered under state law to engage in conservation activities. The Sonoma County Agricultural Preser-

## Central Valley leaders cautious about agricultural easements

Alvin D. Sokolow

**THE** Central Valley is the premier agricultural region in California. But it lags far behind central coastal areas in the accumulation of agricultural easements, an increasingly popular technique for protecting farmland through voluntary landowner action. The 18-county Central Valley has far fewer established local easement programs, participating landowners and agricultural acres under easement than a group of five coastal counties from Sonoma to the north to Santa Barbara to the south. The entire Central Valley in mid-2000 contained only 15% (13,100 acres) of the state's total 84,000 acres under agricultural easements, as compared with 70% (59,000 acres) for the coastal counties.

To investigate the prospects for greater use of agricultural easements in the Central Valley, we interviewed 111 community leaders in 11 Central Valley counties, in 1999 and 2000. The respondents were county and city planning directors, leaders of county Farm Bureau organizations, agricultural commissioners, building industry leaders, agricultural bankers, land appraisers and community activists. In open-ended interviews, mostly in person and averaging about 40 minutes, we asked their familiarity with the technique, its merits, possible local applications and a range of other questions. Not all interviewees

responded to all questions.

While the results are not directly comparable to interviews conducted with landowners involved in three major easement land-trust programs in the northern Bay Area and Yolo County, the findings suggest important regional differences. Most notably, Central Valley respondents expressed more cautious views about use of easements to protect farmland.

### Survey synopsis

**Familiarity.** About four fifths of respondents were generally familiar with the easement technique, with most reporting an elementary level of knowledge. Planners, land appraisers and agricultural commissioners tended to be the most knowledgeable, with bankers and building industry people the least.

**Positive impressions.** As to whether easements on farmland are a "good idea" in concept, positive responses outnumbered negatives 32 to 5. But a larger number (50) said "maybe" or expressed some uncertainty, citing issues of funding, location, relation to planning tools and community support (N = 87).

**Local impact.** As to whether easements are a "good idea" for respondents' particular localities, responses were positive by 51 to 34, with another 34 indicating conditional approval (N = 90).

**Pros and cons.** Benefits to landowners topped the list of advantages, while problems with location and perpetuity were tied for top disadvantages (fig. 1).

**Perpetuity.** There was a 19 (pro) to 15 (con) split on whether easements should last in perpetuity, with another 13 respondents having positive but cautious views (N = 47).

**Nonprofits.** By a 46 to 11 margin, respondents favored nonprofit land trusts over public agencies to manage easement programs (N = 57).

**Priorities.** Location in relation to urban growth was mentioned by 37 respondents as an important priority for programs acquiring easements, while 19 each cited quality of land or multiple priorities (N = 75).

### Consideration of easements

We also asked 33 farmland owners, mostly local Farm Bureau leaders, whether they would be interested in selling easements on their agricultural land. This was clearly a hypothetical question, since all but one of the interviewees had never had the opportunity to consider an easement sale. And in all but two or three cases, the farmland they owned was distant from the nearest urbanization and had virtually none of the development potential that programs frequently seek as a qualification for an easement acquisition. Nonetheless, the responses were mixed: 16 yes, 8 no, 9 maybe.

One Kings County farmer we interviewed said: "I manage 40 acres in walnuts for a family group. It's not really close to development. But some of my brothers think that there will be a shopping center out there in about 40 years, and so they're betting on the future. I don't think that's realistic. But no, we would not be interested in getting into an easement."

Another in Kern County noted: "I would have to bring the family together and say, 'Would you be interested in doing this sort of thing?' We all have our homes here. There are three of us. I'd have to get them to think about the future. Do they really want to hold on to this facility?"

### Positive but cautious

In general, the Central Valley leaders were mildly positive but cautious about the merits of agricultural easements and the possibility of expanding their use in California's premier agricultural region. Few respondents rejected the technique outright. But there also were few enthusiastic supporters. A high degree of uncertainty ran through the responses, with questions raised about perpetuity and other practical issues.

In responding to our questions, many interviewees may have been constrained by limited knowledge about

Jack Kelly Clark



In California's agriculturally rich Central Valley, community leaders had generally positive impressions about easements but there were few enthusiastic supporters. In Patterson, land was offered for subdivision.

the workings of the easement technique. Improving this knowledge base is the goal of several organizations with educational activities in the region, notably the Great Valley Center, American Farmland Trust and California Department of Conservation. The more critical limitation, however, may be the absence of functioning agricultural easement programs in most parts of the Central Valley, perhaps the result of limited citizen interest and local government support (see p. 15).

A.D. Sokolow is Public Policy Specialist, Human and Community Development, UC Davis.

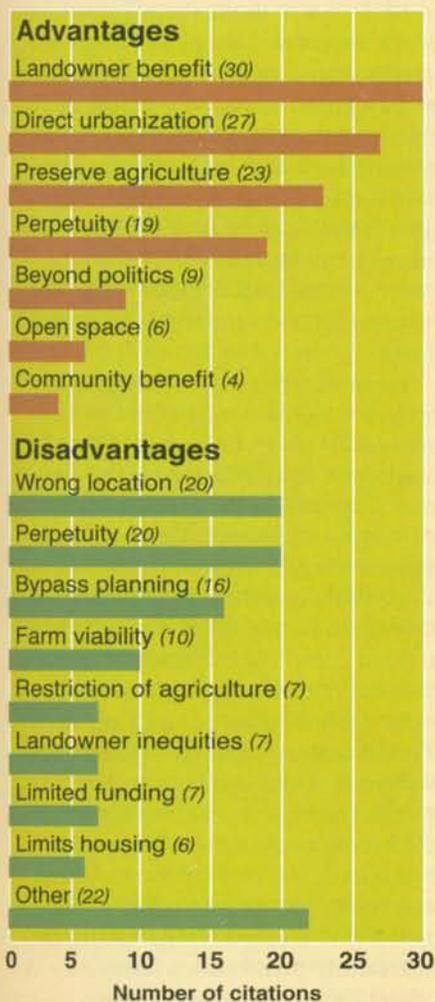


Fig. 1. Advantages and disadvantages of agricultural easements, as cited by Central Valley leaders. Based on interview responses from 76 community leaders in 11 Central Valley counties.

vation and Open Space District is a public district formed by a county ballot initiative in 1990 and operated by a county government agency. Their easements total more than 53,000 acres, nearly half of all agricultural easement acres in California. Both the Marin and Sonoma county programs are among the six largest local agricultural easement programs in the nation (Bowers 2001).

We surveyed 46 landowners in the Sonoma, Marin and Yolo county programs by phone and in person from February to August 1999, using a standardized interview guide. The interviews ranged from 15 minutes to 1 hour and were taped and later transcribed for analysis. Interview topics included questions about motivations, negotiations with land trusts, perceptions about program success and other experiences related to their conservation easement. The 46 landowners represented 44% of the total of 105 landowners participating in the three programs. Thirty-seven had sold such easements in recent years; the other nine owners had recently purchased parcels with easements already in place (table 1). Their parcels represented a majority (55%) of the total 53,000 easement acres held by the three programs at that time. The average parcel size was 530 acres.

### Motivations for selling rights

The survey revealed some common threads about why landowners made the decision to sell development rights (table 2). While the 37 original sellers of easements gave seven discrete reasons, there were obvious similarities and overlaps. Combined, three major motivations surfaced: to preserve land for farming and/or open space (mentioned by 25 respondents); to provide cash for savings and retirement, for farm improvements or to reduce debt (34 mentions); and to serve fam-

ily needs such as estate settlements and generational transfers (19 mentions). Several landowners received tax benefits by donating a partial portion of their easement.

Most respondents cited a combination of at least two of these motivations. Certainly cash was a powerful incentive, since giving up development rights typically meant that the landowners received at least several hundred thousand dollars per transaction and more than a million dollars in a few cases. But in many cases the cash was valued mainly as a vehicle for accomplishing one or another of the other objectives.

Personal attachment to a parcel was another widely held sentiment, with many respondents noting a long history of family ownership and the importance of their farms as home sites. Several landowners spoke about the need to facilitate an intergenerational transfer.

The immediate goal for some was to overcome a fragmented family ownership that made continued farming uncertain. The cash from the easement

TABLE 1. Survey of 46 easement sellers, landowner and parcel characteristics\*

	Marin†	Sonoma	Yolo	Total
No. landowners	15	25	6	46
Owner at time of easement sale	12	23	2	37
Later purchaser	3	2	4	9
<b>Reside on easement?</b>				
Yes (no)	15 (0)	13 (12)	0 (6)	28 (18)
<b>Farm operator status</b>				
Full-time (retired)	8	8	3	19
Part-time	4	6	—	10
Not involved in operation	3	4	3	10
Parcel formerly in agriculture	—	7	—	7
Family members involved in operation	8	7	1	16
<b>Family ownership</b>				
At least two generations	11	10	1	22
Same generation, 20+ years	2	5	—	7
10–20 years	2	3	1	6
0–10 years	—	7	4	11
<b>Principal commodities</b>				
Dairy, silage	9	5	—	14
Cattle, sheep	5	7	—	12
Grapes	1	2	1	4
Row crops	—	—	5	5
Tree crops	—	2	—	2
Poultry	—	1	—	1

\* Source: landowner interviews.

† Marin = Marin Agricultural Land Trust; Sonoma = Sonoma County Agricultural Preservation and Open Space District; Yolo = Yolo Land Trust.

TABLE 2. Motivations cited by landowners for selling easements

Motivation	Marin*		Sonoma		Yolo		Total	
	#	%	#	%	#	%	#	%
Preserving land for farming	7	5	88	35	2	100	17	46
Cash for nonfarm use	7	58	8	35	—	—	15	41
Passing land to next generation	7	58	3	13	—	—	10	27
Cash to invest in farm operations	4	33	4	17	2	100	10	27
Settling estate problem	3	25	6	26	—	—	9	24
Cash to reduce farm debt	3	25	5	22	1	50	9	24
Preserving land for open space	—	—	8	35	—	—	8	22
No. landowners responding	12		23		2		37	

\* Marin = Marin Agricultural Land Trust; Sonoma = Sonoma County Agricultural Preservation and Open Space District; Yolo = Yolo Land Trust.

sale could help the younger family members purchase the parcel from the older generation or prepare for the transition by paying down existing farm debt or improving the farm operation. In one situation, the farm operator used the proceeds from the easement sale to secure full control of the land by buying out the ownership shares of his siblings.

Surprisingly, the permanence of a deed restriction — the issue of keeping the land in agriculture in perpetuity, essentially forever — did not discourage landowners from selling easements. However, this sample includes only participating landowners and not those who might have chosen not to sell because of this restriction. Only five respondents expressed some discomfort with the permanent nature of their easement. In fact, for the majority of landowners, perpetuity was considered an advantage because their goal was to pass the land on, undeveloped, to future generations. One respondent did argue for less-than-permanent easements because he felt they were more compatible with the economic fluctuations in agriculture.

For most of the nine landowners in the three counties who purchased their properties after the development rights had been removed, having an easement in place was considered an advantage. The principal reason, they said, is that it made the purchase more affordable. By eliminating the possibility of development, an easement in effect reduces the market value from a speculative to a farm production level.

### Program shortfalls

When asked about the effectiveness and impact of the program's public goals such as slowing urbanization and preserving farmland, the great majority (83%) of landowners stated that the programs were successful. However, they expressed some common reservations and concerns about the easement programs, including that they:

- Pay too much for easements on particular parcels.
- Acquire easements on parcels that would not be subject to development in any case.
- Do little to stem the continuing loss of farmland or maintain the long-term viability of local agriculture, due to larger economic forces.
- Are too bureaucratic, have too large a staff or conduct affairs in a political manner.
- Have insufficient funds to continue easement program purchases.
- Are unsympathetic to farmers.

### Landowner-program relationship

At the heart of the easement process is the relationship between the landowner and the land trust or other conservation organization that acquires the easement, whether through purchase or donation. It begins with a conversation about the possibility of a landowner entering into an easement transaction, and continues through formal negotiations over price and other terms. After acquisition, the agency periodically monitors compliance with the easement terms. Land-

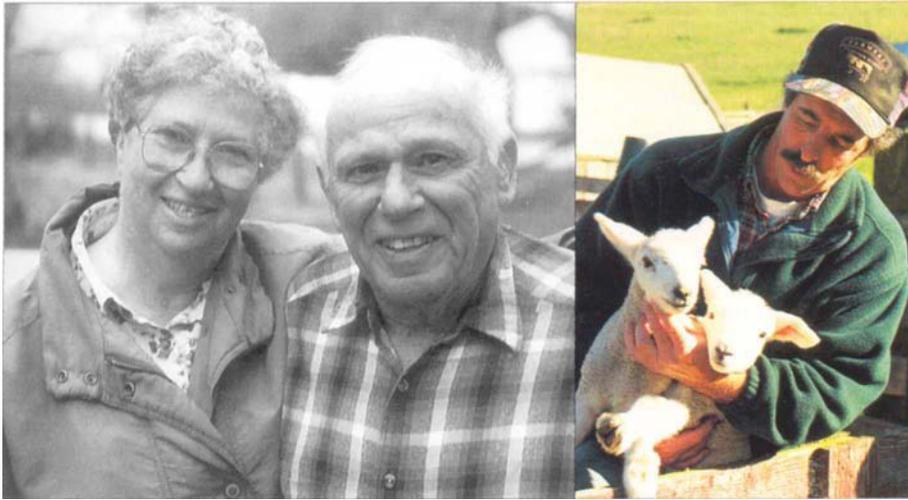
owners may also be involved in the organization's other activities.

We asked the 37 landowners in three counties who had sold easements to describe their easement-related experiences with the land trust or open space district. While landowners were generally positive about their experiences, they also had specific recommendations for how the three organizations could improve their relationships with landowners. The majority of the comments centered on negotiating easement terms and the agency's ongoing monitoring of their properties.

**Negotiations.** Discussions between the landowner and the conservation organization usually focus on two areas: the price, and changes in the use and character of the covered parcel that the easement will allow. One area of landowner concern was the time it took in some cases to negotiate and complete a transaction. Various factors can complicate and lengthen the process: disagreements over price that require more than one appraisal, landowner consultations with attorneys or consultants, or delays until the land trust receives the funds to close the deal.

One landowner in Yolo County, who purchased a parcel after the easement was in place, had no idea that he wouldn't be able to build a home because of specific restrictions named in the deed. Landowners suggested that programs should seek ways to clarify and expedite easement negotiations and terms. They felt that if programs provided complete information upfront, and made sure purchasers understood the easement terms including the conditions of monitoring and use restrictions, misunderstandings and negative feelings would be reduced.

The most frequent sticking point seemed to be the construction of additional residences or farm outbuildings. Landowners wanted the flexibility to house family members or farmworkers. Several landowners expressed the opinion, when asked if they would participate again, that they would revise their easement deeds to provide more flexibility for family



Ultimately, landowners must make a sometimes difficult, personal decision about whether to sell an easement. In Marin County, some who did include: *left*, Marin Agricultural Land Trust co-founder Ellen Straus and her husband William, of Straus Family Creamery, an organic dairy on Tomales Bay; and *right*, sheep rancher Bill Jensen of Tomales.

housing. This included the location, size and number of buildings allowed. While the conservation organization generally tries to tailor these terms as closely as possible to the expressed needs of individual landowners, we found that some organizations were more lenient than others in defining the parameters of an easement.

**Monitoring.** Contact between the landowner and the conservation organization does not end at completion of the easement transaction. The easement terms require that the relationship continue indefinitely to ensure that landowners adhere to the restrictions that have been placed on the property. Program staff or volunteers periodically monitor the uses and conditions of the property, typically through annual site checks and other forms of data collection.

Monitoring of easements was controversial among some of those we interviewed. Of the 33 respondents who commented on the subject, 14 reported negative experiences or perceptions of the process. Landowners do not like intrusions on their property regardless of whether they agreed to them on paper. Landowners suggested that programs monitor easement-restricted parcels as a cooperative rather than adversarial process. They suggested that the personnel responsible should be sensitive to local circumstances, be knowledgeable about local agricul-

tural practices and provide more practical assistance with improving land management practices.

### Statewide applications

Easements are unquestionably a flexible tool for advancing the individual, family and business goals of farmland owners, as suggested by the owners who sold easements in three California counties. They liked the economic and conservation benefits of the transactions, and were largely positive about the negotiations and other experiences with conservation agencies. Nonetheless, while the easement programs seemed to work for farmers in the northern Bay Area counties and Yolo County, it's not clear that they will appeal to landowners in other parts of the state and, in particular, the agriculturally rich Central Valley. This region differs from the three counties we surveyed in having a greater diversity of agricultural crops, no coastal zones to justify the protection of farmland as open space, less apparent community support for land preservation programs and perhaps a more conservative agricultural community.

*E. Rilla is Community Development Advisor and County Director, UC Cooperative Extension, Marin County.*

## What landowners say about their conservation easements

Compiled by Ellen Rilla

"It allowed us to buy the dairy and keep the land in agricultural production. It would have been very difficult otherwise. Now I plan to keep this in agricultural production and hand it down to future generations."

— *Nicasio farmers who used easement funds to purchase leased dairy*

"The price of preservation is high for those who retain ownership of the land. A big problem we face is inheritance tax. The land has escalated in value way beyond what we're able to pay. I'm 60 years old and in a position to be both inheriting it and passing it on. I would have had to sell the farm, and that's the last thing I want to do."

— *Marin landowner*

"We didn't have any debt on the property. We looked at the easement in terms of the money it would bring. I haven't done anything more with it than draw interest. It's a long-term investment gain, or maybe we can use it for houses (on the land) for the children."

— *Sonoma landowner*

"More farm properties would get carved up upon death of the owners because of estate issues. The long-term effect of this program is to keep properties intact."

— *Sonoma landowner*

"The easement program gets around the zoning, which can be changed by the board of supervisors. Nothing is forever with zoning — it can be changed on a whim. The easement is a forever thing."

— *Yolo landowner*

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# Red imported fire ants threaten agriculture, wildlife and homes

Karen M. Jetter ■ Jay Hamilton ■ John H. Klotz

*The red imported fire ant, a pest newly introduced into California, threatens households, agriculture and wildlife. This study estimates the costs and benefits of a public program to eradicate the ants. The results show that almost all agricultural activities would be affected should the ants become established; however, households would incur the majority of costs. The total estimated cost if red imported fire ants become established would be between \$387 million and \$989 million per year in California. Given current funding levels for eradication of red imported fire ants, for the expected benefits to be at least as great as the expected costs, the probability of successfully eradicating the ants needs to be at least 0.65% if the annual costs of establishment are \$989 million and 1.67% if they are \$387 million.*



**THE** discovery in 1997 of the red imported fire ant in almond orchards in the San Joaquin Valley and, more recently, in many parts of Orange, Riverside and Los Angeles counties, has raised concerns about the effects of its recent introduction and potential spread throughout California. (In October 2001, red imported fire ants and mounds were discovered in Sacramento County. See p. 4). This pest is of particular significance because it threatens urban, agricultural and wilderness areas. Given the magnitude of the effects the ants have had in southern states, an examination of the potential costs to California should the ant become established is important in determining the appropriate policy response.

Due to its large populations and omnivorous diet, the red imported fire

ant (*Solenopsis invicta*) can have a tremendous impact on rural and urban environments. Several hundred thousand worker ants live in large, mounded nests that can damage mowing and harvesting equipment. Cultivation of row crops destroys the mounds, but they may still form along field edges and in perennial crops such as tree fruits, nuts and grapes. The aggressive ants swarm out and sting humans or animals that disrupt their nests. In order to sting, they must first grab the skin with their mandibles for leverage, and then curl their abdomens to insert the stinger. The venom contains piperidines, which cause a burning sensation, and proteins, which can cause life-threatening anaphylactic shock in a small percentage (< 1%) of the population. Their sting causes a white pustule to form on the skin.

All: Texas A&M University



Red imported fire ants, *top*, were first discovered in California in 1997 on bee shipments from Texas. Infestations are sporadic in California, but in the southeastern United States they are a major pest, building mounds, *above*, that can damage agricultural equipment. They also damage electrical equipment and sting animals and people.

**Clockwise from upper left: Red imported fire ant male; queen; worker; and various sizes of workers.**



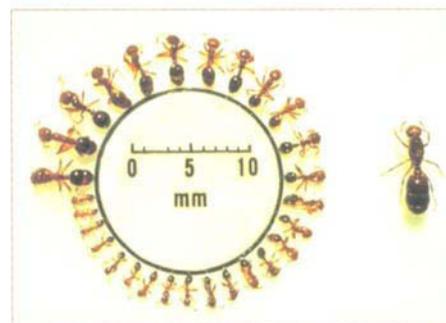
Lloyd Davis, Jr.



Lloyd Davis, Jr.



Texas A&M University



Texas A&M University

The ants are also known to cause extensive damage to irrigation lines. For unknown reasons, they aggregate near electrical fields where they can cause short circuits or interfere with switches and mechanical equipment such as water pumps, computers and air conditioners. Even more serious is when they infest traffic signals and airport landing lights. They also reduce biodiversity and threaten endangered species. Other species of ants, invertebrates and vertebrates are eliminated when they compete with red imported fire ants for limited resources.

We estimate that if the ants become established, the total costs (for all years of establishment) would be between \$3.9 billion and \$9.9 billion depending on how they adapt to the California environment. The costs are greater than those estimated for the establishment of other recently introduced pests, such as avocado thrips, and similar to the potential costs to California agriculture if the Mediterranean fruit fly became established (Coppock and Kreith 1999; Hoddle et al. in press).

A public program now under way to eradicate the ants may prevent, lessen or delay the projected losses. The total cost of the current program to taxpayers and the nursery industry is estimated at \$65.4 million. Because there is some probability that the red imported fire ant eradication program will not be successful, the expected benefits need to be compared with the expected costs. The expected benefits or costs are equal to the total benefits or costs adjusted by the probability of success for the eradication program. The probability of successfully eradicating red imported fire ants needs to be at least 1.67% for the low-level damage estimate of \$387 million per year and 0.65% for the high-level esti-

mate of \$989 million per year in order for the expected benefits to be greater than the expected costs.

Only the policy of total eradication, compared to allowing the ants to become established, is considered in this analysis. Other potential policies would be to contain the spread of the ants, to slow the rate of spread and establishment, or to invest in research on more effective pest controls, including biological controls. Obtaining appropriate estimates for these options is beyond the scope of this research at this time.

### The ants arrive

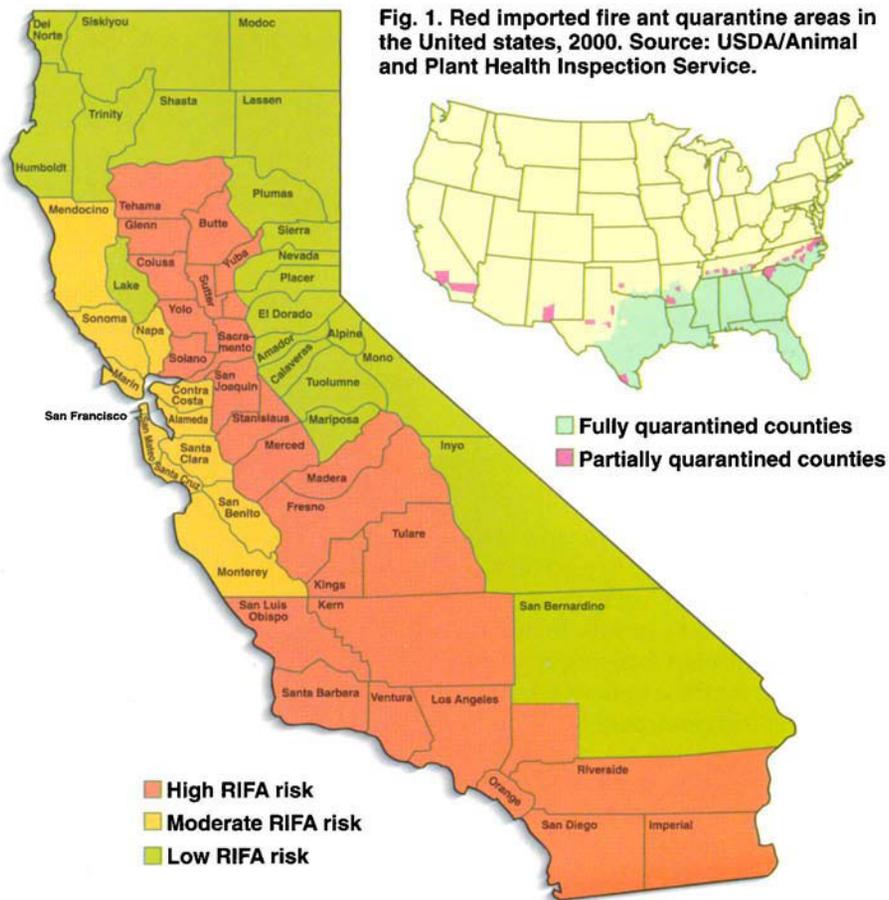
Red imported fire ants originate from lowland areas of South America, and were most likely introduced into the United States around 1940. At that time several native fire ant species thrived in the Southeast and the presence of another exotic one created little concern. By the 1950s, however, their rapid spread (sometimes more than 100 miles per year) and more aggressive behavior alarmed the public. The ants' current geographic distribution includes all of the southern states from Florida to Texas, and as far north as southern Virginia, Tennessee, Arkansas and Oklahoma (fig. 1).

Although the U.S. Department of Agriculture and California Department of Food and Agriculture (CDFA) have maintained quarantines regulating the movement of soil, hay and equipment from regions inhabited by red imported fire ants, over the last 15 years they have been intercepted on numerous occasions at California border stations, and periodic outbreaks have occurred in several counties. The ants arrived on trucks, trains or other vehicles. In 1997, they were identified on bee shipments from Texas destined for almond orchards in the San

Joaquin Valley.

Numerous colonies were detected in Orange and Riverside counties in October 1998. This was the first time the ants had been found on residential as well as commercial property. As a consequence, state and federal quarantines were imposed on all of Orange County, parts of Riverside County near Indio and Moreno Valley, and a small section of Los Angeles County. From the size and distribution of these infestations, it appears that red imported fire ants may have been established and spreading in the Trabuco Canyon area of Southern California for several years.

There is no way of predicting how far and how fast the ants will spread in California. Warm temperature and moisture are critical for their survival. Scarce water makes the desert regions of California inhospitable to the ants but, due to irrigation, they are able to thrive on golf courses, nurseries, horse



**Fig. 1. Red imported fire ant quarantine areas in the United States, 2000. Source: USDA/Animal and Plant Health Inspection Service.**

**Fig. 2. Red imported fire ant (RIFA) colonization risk in California. Source: California Department of Food and Agriculture.**

facilities and turf farms. The ants prefer to nest in moist soil often found in housing developments and irrigated farmland, or adjacent to watering holes on rangelands, lakes, ponds and streams. It is unlikely, however, that red imported fire ants could survive in the cooler climates of the Sierra Nevada and Northern California.

### Estimating costs

Households, agriculture and wildlife are all affected by red imported fire ants. However, the costs and benefits of the ants' spreading throughout California would not be evenly distributed. Some households, farms or ranches could incur significant costs from large infestations, while nearby homes and agricultural operations may have little or no damage.

The costs estimated in this study are based on average costs from studies of damage by red imported fire

ants in the southeastern United States. Since the ants are new to California, empirical values must be based on infestations elsewhere. These values are applied to the susceptible regions in California as determined by climatic factors and adjusted, where applicable, to account for low- and high-risk areas. Low-risk areas are along California's Central Coast, while high-risk areas are located in the Central Valley and Southern California (fig. 2).

### Costs to urban households

The potentially serious effects of ants in urban areas include medical problems such as skin inflammations and allergic reactions to ant venom, reduced use of recreational facilities, damage to communications and electrical equipment, and the expense and indirect costs associated with increased use of pesticides (Dukes et al. 1999). Urban households can incur

costs to treat mounds, repair damage to electrical equipment and pay medical and veterinary bills. For example, in South Carolina households, the average total annual cost per household due to the ants was \$80 (\$33 in low-risk areas and \$104 in high-risk areas) (Dukes et al. 1999).

Given the wide range in costs in the South Carolina survey and climatic conditions in California, we used three methods to estimate the economic effects of red imported fire ant infestations on urban households. The first was to multiply the number of households in susceptible counties by the average cost per household for all households. The second method was to multiply the number of households in the low-risk counties by the average low-risk cost, and the number of households in the high-risk counties by the average high-risk cost, then add the two together. The third method was to multiply the number of households in susceptible counties by the average costs per low-risk household.

In 1999, the total number of California households in susceptible counties was 10,363,432 (DOF 2000). In the low-risk counties there were 2,711,036 households and in the high-risk counties 7,652,396. Total estimated cost of red imported fire ant damage to urban households is \$829 million when average costs for all households are used to calculate the total, \$885 million when cost is calculated by region, and \$342 million when the average low-risk cost is used for all susceptible households.

### Costs to agriculture

**Tree crops and vineyards.** Tree crops and vineyards use hand labor throughout the year for tasks such as pruning, raking and harvesting. In fields infested with the ants, crews may not be able to enter because of the ants' aggressive nature and painful stings, or they may request a higher fee to compensate for additional risks. Alternatively, producers could treat

TABLE 1. Estimated annual costs of red imported fire ants on California tree and vine crops

Crop	Acres	Farm receipts 1,000s \$(1,000s)	Additional costs to industry*			Farm receipts		
			Acreage affected			Acreage affected		
			10%	25%	40%	10%	25%	40%
Almond	456	1,165,150	2,509	6,273	10,037	0.22	0.54	0.86
Apple	39	207,151	216	541	865	0.10	0.26	0.42
Apricot	21	57,309	114	286	457	0.20	0.50	0.80
Avocado	58	272,406	321	802	1,283	0.12	0.29	0.47
Cherry	18	79,103	96	241	386	0.12	0.30	0.49
Fig	15	18,149	81	203	325	0.45	1.12	1.79
Grapefruit	17	73,794	93	232	371	0.13	0.31	0.50
Grape	747	3,178,940	4,111	10,277	16,444	0.13	0.32	0.52
Lemon	49	347,329	271	677	1,083	0.08	0.19	0.31
Nectarine and peach	110	556,535	604	1,511	2,417	0.11	0.27	0.43
Olive	34	73,677	185	463	741	0.25	0.63	1.01
Orange	205	906,317	1,125	2,813	4,500	0.12	0.31	0.50
Pear	19	90,479	105	264	422	0.12	0.29	0.47
Pistachio	65	181,678	358	895	1,431	0.20	0.49	0.79
Plum	43	199,801	238	595	952	0.12	0.30	0.48
Prune	86	151,822	471	1,176	1,882	0.31	0.77	1.24
Walnut	202	344,848	1,109	2,774	4,438	0.32	0.80	1.29
<b>Total</b>	<b>2,183</b>	<b>7,904,486</b>	<b>12,009</b>	<b>30,022</b>	<b>48,035</b>	<b>0.15</b>	<b>0.38</b>	<b>0.61</b>

\* Treatment costs are \$55 per acre for one application with the insect growth regulator methoprene.

fields with insecticides and control red imported fire ants before crews enter. In our analysis, we assumed that producers would treat fields twice a year to control the ants with the insect growth regulator methoprene. Annual application costs were estimated at \$55 per acre. While not included in this analysis, additional costs may accrue in order to meet quarantine regulations.

The extent to which the ants would establish in groves, orchards and vineyards may vary depending on previous treatments and agro-climatic conditions. Therefore, a range of acreage is used to estimate the additional costs to tree fruit, nut and vine industries in California. We used a low-impact level of 10% of total acreage affected, a medium one of 25% and a high level of 40%, based on interviews with scientists familiar with red imported fire ant problems in Florida and Arkansas.

Total estimated increases in costs for all crops would range from \$12 million at low infestation levels, to \$30 million at medium levels, to \$48 million at high levels. Absolute increases in costs would range from

\$81,000 for figs at low-impact levels to \$16.44 million for grapes at high levels (table 1).

While the estimated dollar amounts are substantial, as a percentage of total farm receipts they are usually less than 1%, even when 40% of acreage is affected. Costs as a percentage of farm receipts are greatest for figs, walnuts and prunes, and lowest for lemons, nectarines, peaches, pears, apples and plums.

**Citrus.** Red imported fire ants may also damage young citrus when they build nests near the base of trees 1 to 4 years old. The ants feed on the bark and cambium to obtain sap, often girdling and killing young trees. They also chew off new growth at the tips of branches and feed on flowers of developing fruit. Dead trees must be replanted, raising the costs to establish an orchard. Based on field experiments in Florida, nursery stock mortality in untreated groves increased three- to fivefold per acre, and in some places entire newly planted groves were lost due to ant feeding (Banks et al. 1991).

To decrease tree mortality, growers may choose to treat groves with insecticides for 2 to 3 years until young

trees develop woody bark that the ants cannot chew through. Control undertaken during grove establishment would increase investment costs, and treatment costs must be depreciated over the life of the grove. When groves are treated with two applications of methoprene at an annual cost of \$55 per acre, establishment costs double or triple if the grove is treated for 2 or 3 years, respectively. Depreciation of the additional investment costs to establish the grove would increase annual cash costs by \$9 per acre when treatments last 2 years, and by \$13 per acre for 3 years. This increase is less than 0.5% of the total annual cash costs based on UC Cooperative Extensive farm budgets for citrus (O'Connell et al. 1999; Takele et al. 1998; Takele and Mauk 1998).

**Vegetables and melons.** Because of frequent disking, red imported fire ants build nests around the edges of fields planted in vegetable crops. From there they enter fields and damage crops primarily by consuming developing fruit, seeds, roots or tubers. Documented losses from the ants include a yield loss of 50% on eggplants in Florida and a sunflower plant loss of 2.4% to 4.0% in Texas (Adams 1983; Stewart and Vinson 1991). In the sunflower field no further damage was observed after treatment with insecticides.

It is often the case that crop damage will not be significant enough to economically justify treatment. However, many vegetable and melon crops are hand-harvested, so growers may need to treat fields with two applications of methoprene to protect workers.

Total potential costs to the California vegetable and melon industries would range from \$3.7 million when only 10% of acreage is infested, to \$9.2 million at 25% infestation and \$14.8 million at 40% (table 2). While the dollar figures seem large, as a percentage of farm receipts they would be less than 1% in all cases and under 0.5% in most, even when up to 40% of acreage is affected.

TABLE 2. Estimated annual costs of red imported fire ants on California vegetable and melon crops

Crop	Acres	Farm receipts	Additional costs to industry*			Farm receipts		
			Acreage affected			Acreage affected		
			10%	25%	40%	10%	25%	40%
	1,000s	\$(1,000s)	\$(1,000s)			%		
Artichoke	10	68,405	55	138	220	0.08	0.20	0.32
Asparagus	31	109,624	171	428	685	0.16	0.39	0.63
Bean, fresh	5	25,758	25	63	101	0.10	0.25	0.39
Broccoli	120	467,088	660	1,650	2,640	0.14	0.35	0.57
Brussels sprout	3	21,715	18	44	70	0.08	0.20	0.32
Cabbage	14	74,401	76	191	306	0.10	0.26	0.41
Cantaloupe	63	240,525	345	861	1,378	0.14	0.36	0.57
Cauliflower	39	189,263	213	533	853	0.11	0.28	0.45
Celery	24	227,443	133	333	534	0.06	0.15	0.23
Cucumber	6	52,676	35	87	139	0.07	0.16	0.26
Garlic	34	220,199	184	461	737	0.08	0.21	0.33
Honeydew	21	71,720	113	282	451	0.16	0.39	0.63
Lettuce, head	142	868,571	778	1,946	3,113	0.09	0.22	0.36
Lettuce, leaf	42	261,755	231	578	924	0.09	0.22	0.35
Lettuce, romaine	27	156,520	149	371	594	0.09	0.24	0.38
Onion	39	169,254	214	534	855	0.13	0.32	0.50
Pepper, bell	22	162,707	118	296	473	0.07	0.18	0.29
Spinach, fresh	15	84,816	83	208	332	0.10	0.24	0.39
Watermelon	17	84,216	93	233	373	0.11	0.28	0.44
<b>Total</b>	<b>672</b>	<b>3,556,651</b>	<b>3,694</b>	<b>9,236</b>	<b>14,777</b>	<b>0.10</b>	<b>0.26</b>	<b>0.42</b>

\* Treatment costs are \$55 per acre for one application with the insect growth regulator methoprene.

**Field crops.** Nonyield damages to field crops such as wheat, rice and cotton include downtime to repair combines, electrical problems with pumps and machinery, other equipment damage, building damage and medical expenses. In mowing weeds or cutting alfalfa, farm operators must raise the cutting bar to prevent damage from nest mounds, switch from sickle bar to disk-type cutters, repair equipment damaged by the mounds or use insecticides to destroy colonies. Because the ants are previously established in regions with rain-fed agriculture, costs involving damage and repair to irrigation equipment are not available.

In a survey of Arkansas field crop producers, nonyield costs of the ants per farm were \$1,478 per year (Jones et al. 1997). More than half of these costs were due to combine damage and downtime for cutter blade repair, followed by electrical equipment repairs. On a per-acre basis, the cost for all yield and nonyield damage was \$1 for rice, \$0.25 for wheat and \$1.35 for hay. In general, it was not cost effective to treat for ants in field crops.

At the same time, red imported fire ants are predators of many agricultural pests. Among cotton pests in California, they would prey upon the tobacco budworm and cotton bollworm. Field experiments in Texas show that the presence of red imported fire ants can significantly decrease bollworms in cotton fields and increase yields (Brinkley et al. 1991). However, because they also damage electrical machinery and clog sprinklers and irrigation equipment, the net impact on profits is ambiguous. Therefore, no losses or benefits are estimated for cotton.

The total number of susceptible field crop farms in California, based on the 1997 Census of Agriculture, is 5,526 (USDA 1999). This includes grain, oilseeds and hay enterprises. The cost per farm is set at the average level incurred by Arkansas growers. Total annual estimated costs for the state are \$817,000 when 10% of acreage is infested, \$2 million at 25% and \$3.3 million at 40%.

Hay growers may have additional costs due to quarantine regulations

since hay stored on the ground can not be moved out of a quarantined area. How this affects growers would depend on the amount of production that would leave the area and the cost of alternative storage. Even if hay is not transported out of the region, growers would need to take precautionary measures against the ants, as horses, cattle and other livestock will not eat ant-infested hay. Quarantine regulations would also require that farm machinery and soil be treated before leaving the area.

**Nursery industry.** All nurseries within a red imported fire ant quarantine area would need to meet quarantine regulations in order to ship plants outside of the region. Open land on which nursery stock is grown would need to be treated once every 3 months, alternating between fenoxycarb and hydramethylnon. In addition, growers would need to treat the individual containers in which the plants are grown. Acceptable treatments include either a drench with chlorpyrifos 30 days before shipping, or incorporating a granular insecticide, bifenthrin, into the soil every 6 months. Because of environmental regulations concerning pesticide runoff and the need to treat frequently with chlorpyrifos, bifenthrin is more commonly used.

Annual costs to treat nurseries for red imported fire ants would be about \$650 per acre. Applications of fenoxycarb and hydramethylnon are \$60 per acre with bifenthrin accounting for the remaining costs. According to the American Nursery and Landscape Association, the treatment cost per container is about 2 cents. Only



**Red imported fire ants will attack both adult and larval insects such as the armyworm, left, on the ground or on plants. As such, they can have the positive effect of controlling agricultural pests such as the cotton bollworm. However, they also attack beneficial insects.**

open nursery acreage that produces container plants would be affected by quarantine regulations. Based on the 1997 Census of Agriculture, 28,000 acres in California were devoted to open field nursery production of bedding and flower plants, foliage, potted flowers and other nursery stock (USDA 1999). Because all nurseries within quarantined regions — whether infested or not — must treat in order to ship outside of the quarantine, almost all nurseries would be affected by the regulations. Therefore, we estimated total costs to the nursery industry on all open field acreage to be \$18.2 million. In addition, nurseries would be required to be inspected for the ants by placing bait out quarterly. Additional costs for inspection and certification are about \$1.40 per acre.

Greenhouses that use containers placed on benches are exempt from the quarantine regulations. However, for worker safety and to protect electrical equipment, greenhouse operations would still need to treat the perimeter of buildings if they are infested.

Sod growers are also affected by quarantine regulations. Treatment with the insecticide chlorpyrifos would cost \$330 per acre. Based on the 1997 Census of Agriculture, a total of

13,665 acres in California would be affected (USDA 1999) at an estimated cost of \$4.5 million.

**Animal industries.** Red imported fire ants attack cattle and other livestock. They are attracted to mucous membranes in the animals' eyes and nostrils, and their stings cause blindness and swelling, which may cause suffocation. Immobilized animals, such as penned or newborn livestock, are at greatest risk. A survey of Texas veterinarians found that the most common problem was skin inflammations from ant stings (49.6% of all cases), followed by blindness (20.1%), secondary infections (14.4%) and injury to convalescent animals (12.3%) (Barr and Drees 1994). Although more than half of the cases seen by the Texas veterinarians involved pets and small animals, mortality associated with red imported fire ants was greatest for cattle. With cattle, however, it was often difficult to determine if the ants caused death or if they were observed on livestock after death.

The ants also infest hay and other feed sources. Livestock may become malnourished or dehydrated when the ants invade their food and water. Cattle will not consume hay, nor will poultry eat infested feed. The agitation caused by ant invasions of poultry

houses has been observed to decrease egg production (personal communication, Lynn Thompson, University of Arkansas). Extra expenses would be incurred to purchase ant-free hay, or to treat buildings to prevent invasions of calving pens, dairy and hog barns and poultry houses.

Conversely, the ants may benefit the cattle industry by preying on immature ticks and horn flies. Because these pests are vectors, red imported fire ants may decrease the incidence of certain animal diseases.

**Rangeland.** Costs to ranchers include damage to electrical and hay harvesting equipment as well as cattle injury and loss. In a survey of Texas ranchers, 71% reported some type of economic loss due to red imported fire ants (Teal et al. 1998). Average losses were reported by county with the largest damage levels estimated at \$28.06 per acre; however, many counties in the drier western regions had damages of less than \$2 per acre. Even though damages in Texas were averaged on a per-acre basis, about 95% of the total costs occurred on about 5% of the land. Most costs would be from damage around buildings, electrical equipment and water sources.

Because climate patterns in California better resemble western Texas, costs in California are more likely to resemble those incurred by ranchers in Texas' western counties. Furthermore, a significant proportion of rangeland in California is in counties too cold or dry to support the ants. If rangelands in unsusceptible counties are excluded, 15,759 acres are potentially at risk. This includes private rangelands,

## California endangered species at risk

Red imported fire ants disrupt ecosystems and endanger wildlife by preying on other insects; eating mammal, reptilian and bird newborns, and soft-shelled eggs; destroying habitat; and reducing food sources. The following endangered species could be at even greater risk if the ants become widely established in California.



Spotted owl chick

UC Natural Reserve System

### Insects

Beetle, delta green ground  
 Beetle, valley elderberry longhorn  
 Butterfly, bay checkerspot  
 Butterfly, El Segundo blue  
 Butterfly, Lange's metalmark  
 Butterfly, lotis blue  
 Butterfly, mission blue  
 Butterfly, Myrtle's silverspot  
 Butterfly, Oregon silverspot  
 Butterfly, Palos Verdes blue  
 Butterfly, San Bruno elfin  
 Butterfly, Smith's blue  
 Fly, Delhi Sands flower-loving  
 Moth, Kern primrose sphinx

### Predation of newborns/eggs

#### Ground-nesting birds

Goose, Aleutian Canada  
 Plover, western snowy  
 Rail, California clapper  
 Rail, light-footed clapper  
 Rail, Yuma clapper  
 Shrike, San Clemente loggerhead  
 Tern, California least  
 Towhee, Inyo California  
 Pelican, brown

#### Low tree-nesting bird

Gnatcatcher, coastal California\*  
 Vireo, least Bell's\*

#### Soft-shelled eggs

Frog, California red-legged  
 Salamander, desert slender  
 Salamander, Santa Cruz long-toed  
 Toad, arroyo southwestern

\*Possible indirect effects

### Eggs in soil of dried pools

Fairy shrimp, vernal pool  
 Tadpole shrimp, vernal pool

### Reptiles/Mollusk

Lizard, blunt-nosed leopard  
 Lizard, Coachella Valley fringe-toed  
 Lizard, island night  
 Snail, Morro shoulderband (mollusk)  
 Snake, giant garter  
 Snake, San Francisco garter  
 Tortoise, desert  
 Turtle, green sea  
 Turtle, leatherback sea  
 Turtle, loggerhead sea  
 Turtle, olive (= Pacific) Ridley sea

### Rodents

Kangaroo rat, Fresno  
 Kangaroo rat, giant  
 Kangaroo rat, Morro Bay  
 Kangaroo rat, Stephens'  
 Kangaroo rat, Tipton  
 Mouse, Pacific pocket  
 Mouse, salt marsh harvest  
 Vole, Amargosa

### Habitat disruption

Mountain beaver, Point Arena

### Reduction in food source

Condor, California\*  
 Eagle, bald\*  
 Falcon, American peregrine\*  
 Flycatcher, southwestern willow  
 Owl, northern spotted\*  
 Sparrow, San Clemente sage\*  
 Murrelet, marbled\*

TABLE 3. Total estimated annual costs of red imported fire ant establishment in California

Category	Impact		
	Low	Medium	High
	.....\$ (millions) .....		
Tree and vine crops	12.0	30.0	48.0
Vegetable crops	3.7	9.2	14.8
Field crops	0.8	2.0	3.3
Nursery	18.2	18.2	18.2
Sod	4.5	4.5	4.5
Rangelands	5.9	9.5	15.4
Total agricultural	45.1	73.5	104.2
Total household	342.0	829.0	885.0
<b>Total</b>	<b>387.1</b>	<b>902.5</b>	<b>989.2</b>

Bureau of Land Management land and national forest grazing land.

However, the ants should not be a problem on all susceptible acreage. As in the case of agricultural crops, we use different impact levels to indicate the potential range in costs. Because a higher proportion of ranchers than growers reported economic losses from the ants in Texas, a higher range of acreage is used for our analysis. We used infestation levels of 25%, 40% and 65% of all susceptible acres to determine the range in costs. At per-acre costs of \$1.50, estimated total annual potential costs to California cattle ranchers would be \$5.9 million when 25% of rangeland is affected, \$9.5 million for 40% and \$15.4 million for 65%.

### Costs to wildlife

There is substantial evidence that red imported fire ants affect wildlife and reduce biodiversity of native plants and animals (Allen et al. 1994). Due to their enormous population size and foraging efficiency, red imported fire ants become formidable competitors and predators, often displacing native ants and other invertebrates as well as inflicting damage on native reptiles, mammals and ground-nesting birds. Biodiversity in many coastal and low-altitude wilderness areas of California may be at risk.

The ants appear to affect bird and reptilian populations primarily by destroying the eggs and young. One study in Texas found that predation caused a 92% reduction in the number

The red imported fire ant could cost households and agricultural industries between \$397 million and \$989 million annually. Establishment of the ant would be a major nuisance to residents and, in particular, farmworkers. When disturbed, the ants swarm out of mounds and sting. The venom causes pustules and burning, and can result in life-threatening anaphylactic shock in a very small percentage of people.



Close-up. Dan Wojcik; inset, Texas A&M University

of waterbird offspring when natural habitats were not treated for ant infestations (Drees 1994). Of special significance to California are studies that have documented fire ant predation on tortoise and reptile hatchlings. They may also prey on quail. At the same time, many chemical control measures for fire ants can adversely effect wildlife.

Dozens of endangered species are threatened by the establishment of the red imported fire ant (see box, p. 32). Either directly as a source of food for the ants or indirectly from ant predation on a food source, 58 out of California's 79 endangered animal species are susceptible. Insects, young rodents, reptiles, amphibians and ground-nesting birds are directly susceptible.

In addition, several endangered birds, such as the northern spotted owl and bald eagle, may be at risk through reductions in food sources. While no exact value is available for the increased risk of extinction, the public overwhelmingly supports the preservation of endangered species. This potential increase in risk to endangered species, and the efforts and expenditures that would be needed to protect them, represent an as yet unquantified additional cost of ant establishment.

### Total costs of establishment

The spread of red imported fire ants throughout California would result in the establishment of a major nuisance pest. We estimate total annual costs to be between \$387 million at the low-impact level and \$989 million at the high level (table 3). To de-

termine the present value of all losses, each future annual cost must be converted into current dollars (using the discount factor  $[1 - r]^{-t}$  where  $r$  is the discount rate and  $t$  is the future time period) and added together. We assume in this study that if all eradication programs were to stop, it would take 10 years for the ants to spread throughout their range in California and allocate a portion of the annual losses during each of the first 10 years. The present value of all losses is an estimated \$3.9 billion at the low-impact level, \$9.0 billion at the medium level and \$9.9 billion at the high level, using a discount rate of 7%.

Given the large number of households in California, these costs account for about 90% of the total. However, costs to agriculture are still significant and range from \$45.1 million to \$104.2 million per year. Other significant costs would accrue from the disruption of ecosystems, threatening California's native plant and animal

biodiversity and placing dozens of endangered species in California at greater risk of extinction.

### Cost comparison

Eradication efforts are under way to rid California of red imported fire ants. Current public funding of the eradication program was \$8.4 million for the first year beginning in 1999, \$7.4 million for each of the the remaining 4 years with the possibility of a 5-year renewal, plus an additional \$2.0 million one-time allocation. Nurseries within eradication zones established by CDFA also must treat for the ants. Annual costs to comply with quarantine regulations for nurseries in Orange, Los Angeles and Riverside counties are estimated at \$1.5 million per year. The present value of a 10-year eradication program is \$65.4 million.

However, it is possible that California's eradication program will not be successful, given that the ants have been virtually impossible to eradicate in most parts of the South. Therefore the expected costs of eradication need to be compared with the expected benefits based on the probability of success for the second 5-year funding period, as the probability of successfully eradicating the ants during the first 5-year period is widely acknowledged to be approximately zero. An expected value is a total value adjusted by a probability of success or failure. The expected costs are equal to the total costs for both 5-year periods

TABLE 4. Break-even analysis for red imported fire ant in California\*

Impact level	Cost of establishment†	Break-even probability
	\$ (billions)	%
Low	3.9	1.72
Medium	9.0	0.73
High	9.9	0.67

\* For eradication costs of \$65.4 million and a discount rate of 7%.

† These costs represent total estimated expense for all years of establishment.



Red imported fire ants are notoriously difficult to eradicate. In Texas, county extension agent Glenn Avriett, *left*, treats a mound with the insecticide acephate. Ants can damage crops like corn, *right*, but most pesticide treatments would be undertaken to protect farmworkers, agricultural and electrical equipment, and irrigation systems.

less the probability of success for the first 5-year period program times the costs for the second. The expected benefits are equal to the probability of success for the first period times the total benefits plus the probability of failure for the first period times the probability of success for the second times the benefits. The probability of success during the second 5-year funding period is unknown. Consequently, the cost/benefit analysis estimates the probability of success that is needed for the expected benefits to be equal to the expected costs (table 4).

At the lowest impact level the probability of successfully eradicating the ants needs to be at least 1.67% for the expected benefits to be at least as great as the expected costs. As the costs of establishment increase, the break-even probability declines. At the highest cost level the probability of success needs to be at least 0.65%. Whether these probabilities are low enough depends on how rapidly the ants can be discovered and eradicated, given current funding levels. As time elapses, ants spread, costs increase and the probability of success rapidly declines.

### Quick response needed

When an exotic pest is introduced, the regulatory response can be either

attempting to eradicate it, or allowing it to become established and undertaking appropriate management. When eradication programs are pursued, a rapid response is critical because the longer the delay the more time the exotic pest has to spread. As the pest spreads, treatment costs increase exponentially, and the probability of success decreases. In the southern states, eradication efforts have always failed because fire ants recolonized from the surrounding infested areas. Fortunately, the situation in California is different, because outbreaks are isolated. In addition, more effective ant baits have become available and new biological control treatments are being tested. Eradication may be possible in California, if it is executed quickly.

*K.M. Jetter is Postdoctoral Fellow, UC Agricultural Issues Center; J. Hamilton is Assistant Professor, John Jay School of Criminal Justice, City University of New York; and J.H. Klotz is Assistant Extension Urban Entomology Specialist, Department of Entomology, UC Riverside.*

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# Minimum tillage practices affect disease and yield of lettuce

Louise E. Jackson ■ Irene R. Ramirez  
Israel Morales ■ Steven T. Koike



The authors compared lettuce reduced-tillage systems for their effects on soil organic matter, compaction, yield and disease, including, *top to bottom*: the Sundance System for shallow minimum tillage; the minimum-till chisel, for deep minimum tillage; and the minimum-till ripper, part of a four-step deep minimum tillage program designed by Chualar grower Israel Morales (shown). All three treatments retain semipermanent beds.

*Vegetable growers have been experimenting with reduced tillage practices to increase soil organic matter, limit compaction, and reduce fuel and labor costs. We studied soil properties of different tillage practices and compared deep minimum tillage (chiseling and ripping) with shallow minimum tillage for lettuce on a farm in the Salinas Valley. We found that periodic deep minimum tillage is recommended for long-term*

*retention of semipermanent, raised beds in lettuce production. Over a period of several years, deep minimum tillage increased lettuce yield and decreased symptoms of lettuce drop disease, as compared with shallow minimum tillage. Continuous shallow minimum tillage, despite a trend toward higher active and total organic matter in the surface layer of soil, is best used with intermittent deeper tillage to avoid disease and yield losses.*

Tillage is known to decrease soil organic matter, including the active fraction that is largely composed of microbial cells. Soil organic matter is beneficial for nutrient cycling, water infiltration, and in some cases, disease suppression. Tillage can also cause soil compaction of deeper layers of the soil profile, especially in soils that are tilled when wet, as can often occur in vegetable crop systems. Compaction impedes the growth of roots into deep soil layers, restricting the plant's acquisition of water and nutrients. Recently, reduced or minimum tillage in vegetable crop systems has attracted attention as a possible means of increasing soil organic matter and decreasing labor and production costs.

In the Salinas Valley, cool-season vegetables such as lettuce, cole crops and celery are farmed year-round. Most of these crops return little organic matter to the soil after harvest, and soil organic matter has declined markedly during the last century (Wyland et al. 1996). Conventional tillage occurs frequently and intensively, ranging from single passes with culti-

vators for weed control, to ripping, disking and leveling fields between crops. Conventional disking inverts and mixes the soil to a depth of 6 to 10 inches, while ripping penetrates 15 to 20 inches.

Innovative tillage techniques are being developed for vegetable production. At one extreme are no-tillage systems, in which crop residues are left on the soil surface and little soil disturbance occurs. Another option, which is examined here, is to retain semipermanent, raised beds for multiple crop seasons. California vegetable growers often call this *reduced tillage* or *minimum tillage*, even though it does not leave significant amounts of plant residue on the soil surface. Growers retain beds to reduce time, fuel and labor costs that accrue from disking and re-shaping beds between each crop. We tested the hypothesis that the use of semipermanent beds and minimum tillage may also be beneficial in reducing soil compaction and increasing total organic matter and soil microbial biomass, which serves as a measure of the active fraction of soil organic mat-

**TABLE 1. Bulk density (0–18.5 inches depth) under long-term conventional tillage and four-step deep minimum tillage in four soil types\***

Tillage method	Bulk density (g/cm <sup>3</sup> )			
	Pico	Mocho	Salinas	Cropley
4-step deep till	1.33	1.09	0.79	1.00
	†	NS	‡	NS
Conventional tillage	1.44	1.03	1.09	0.09

\* Soils are ordered along a gradient of increasing clay content. NS = no significant difference.

† T-tests significant at  $P < 0.01$

‡ T-tests significant at  $P < 0.0001$

ter. A concern, however, was that disease severity might increase with minimum-tillage methods that till only the surface soil, because of the accumulation of propagules of soil disease organisms. Lettuce drop disease (*Sclerotinia minor*) is of particular interest because some scientists have found a higher incidence with subsurface drip irrigation and associated mandatory minimum tillage (Bell et al. 1998).

### Types of minimum tillage

Shallow minimum tillage refers to operations such as the Sundance System, a brand-name tillage implement that uses disks and lister bottoms (a kind of shovel) to incorporate crop residues and cultivate the tops and sides of the beds in a single pass. This method tills shallowly (approximately 6 to 8 inches) so that subsurface drip irrigation can be used. Deep minimum tillage, in contrast, is intended to also reduce soil compaction. A minimum-till chisel is designed to simultaneously chisel the furrows to approximately 20 inches in depth with a narrow shank, and disk hill the soil into peaked beds. Another option for deep minimum tillage consists of four tillage operations, which each require one pass consecutively with different implements: the minimum-till chisel; the Sundance System; the minimum-till ripper, which uses angled, broad shanks with floating wings to break the compacted layer across the beds at depth; and finally, a surface rototill/mulcher to smooth the surface and prepare a seedbed. This four-step method, designed by a Salinas Valley grower, requires 1.5 to 2 hours per acre, retains semipermanent beds and tills the soil to approximately 20 inches in depth.

We conducted an on-farm project to evaluate these minimum-tillage options for lettuce production in the Salinas Valley. Farmers' fields offer the opportunity to study alternative management practices under realistic soil conditions, pest pressure and marketing constraints. There are, however, some drawbacks. Farmers are not always able to include control plots or management practices that have potentially detrimental effects on yield, nor are they always willing to spend extra management efforts on truly replicating treatments.

In this project, we had three objectives for studying alternative tillage practices in an on-farm environment. First, we assessed soil bulk density to determine soil compaction on neighboring fields that had been in long-term management with either four-step deep minimum tillage or typical, conventional tillage (disking across, then remaking beds between every crop). Second, we measured the effects of a single episode of intensive conventional tillage (deep chiseling, ripping and laser planing) on a field that had been under long-term management with four-step deep minimum tillage. Third, we compared deep and shallow minimum-tillage practices for effects on soils, crop yield and crop disease symptoms for 3 years.

### Compaction on four soil types

We compared soil bulk density in fields that had been farmed for at least 5 years with four-step deep minimum tillage retaining semipermanent beds, and in fields under a regime of conventional tillage in which beds were remade between every crop. All fields

were managed with sprinkler and furrow irrigation, and planted with cool-season vegetables (e.g., lettuce, cole crops and spinach). We chose fields that were in adjacent lots of the same soil type. The soil types were Pico fine sandy loam, Mocho silt loam, Salinas clay loam and Cropley silty clay. Each set of sampling points was less than 110 yards apart. The samples were taken just before the first spring tillage event in 1998 to eliminate the effect of recent management practices.

Cylinders (20-inch-deep sections of 4-inch-diameter PVC pipe, schedule 40) were driven into the center of the beds to a depth of 18.5 inches. Three cores were removed per sampling site. Soil was removed, dried and weighed to calculate bulk density as grams dry soil per centimeter-cubed. (Multiply by 62.4 to obtain pounds per foot cubed.) Means were compared with t-tests, using the  $P < 0.05$  significance level.

For two soil types, Pico and Salinas, bulk density was significantly lower in the fields managed with deep minimum tillage. For the other two soil types, no significant differences were observed (table 1). These data indicate that compaction may decrease in some cases when beds are retained with the four-step deep minimum-tillage operations as compared with conventional practices that disk and reshape beds between every crop.

### On-farm trial established

An on-farm trial was established in September 1995 near Chualar, in the Salinas Valley. The soil was a Cropley



**Scientists have found a higher incidence of lettuce drop disease (*Sclerotinia minor*) with subsurface drip irrigation and related tillage practices.**

silty clay composed of 5.7% sand, 50.7% silt and 43.6% clay. Total organic carbon and nitrogen were 2.19% and 0.22%, respectively. The field had been in cool-season vegetable production using four-step deep minimum tillage for 3 years. In 1993, 1994 and 1995, one broccoli and one crisphead lettuce crop were produced each year using sprinkler and furrow irrigation. Intensive conventional tillage of the field occurred between Nov. 20 and Dec. 12, 1995, as follows: disked two times, ripped two times, disked five times, chiseled two times, disked four times, laser leveled, chiseled two times and listed (shaped) into beds. The grower's purpose was to increase the uniformity of the field.

Soil samples were taken in September 1995, and again in February 1996. A 1.2-acre grid system of 12 points in a randomized complete block design was established so that each point could be sampled before and after the intensive conventional tillage operations. Soil cores were taken from the center of the beds at two depths, at 0 to 2.4 inches, where lettuce roots are abundant, and at 15.7 inches to 18.1 inches, where a compacted "plow pan" layer typically occurs. All soil samples were subsampled for gravimetric soil moisture content to determine changes in water retention. Net mineralizable nitrogen was measured to determine changes in potential nitrogen supplying power in the top soil layer, where most of the organic matter resides. A 7-day anaerobic incubation procedure was used. Bulk density samples were taken for each depth using brass rings of 3.4-inch diameter that were pounded into the soil. Treatment means were compared with t-tests ( $P < 0.05$ ).

No significant difference in bulk density or net mineralizable nitrogen occurred between the fall and winter samples taken before and after intensive tillage and land planing on soil that had been under four-step deep minimum tillage for several years (table 2). Gravimetric moisture was also similar on both dates in the two layers, suggesting that little change

in water-holding characteristics had occurred. These results suggest that a single episode of conventional tillage had little effect on these soil properties.

### Alternative tillage study

To study the long-term effects of alternative tillage practices on soil properties, crop yield and lettuce diseases, the study area was managed for 3 years with shallow (Sundance System only) and deep (minimum-till chisel) tillage to retain semipermanent beds on strips of 21 yards by 220 yards (0.95-acre plots). These treatments began in April 1996, 4 months after the intensive ripping, disking and leveling operations described above. A third treatment, four-step deep minimum tillage, was done adjacent to these strips, but was not sampled until 1998. Thus, the study area was divided into three strips, with each strip receiving one of three treatments that retained semipermanent beds for the 3-year period: shallow minimum tillage, minimum-till chisel or four-step deep minimum tillage. These strips were each divided into three blocks, 21 yards by 73 yards each. Two samples were taken per block. The same points ( $\pm 15$  feet) were sampled on successive dates at six sampling points for each tillage treatment.

The field was managed uniformly with inorganic fertilizers and sprinkler and furrow irrigation. From 1996 through 1999, one broccoli and one crisphead lettuce crop were produced each year. A cover crop of was grown in the fall of 1998. The lettuce cultivar was Sharpshooter in 1997 and 1998, and Venus in 1999. Bulk density and



In a 3-year study, intermittent deep chiseling and ripping resulted in higher fresh lettuce yield and fewer symptoms of lettuce drop disease. A minimum-till ripper in the field undertakes the last step of the four-step deep minimum tillage program.

moisture were measured at depths of 0 to 2.4 inches, and 15.7 inches to 18.1 inches. In 1999, these were also measured at 7.9 inches to 10.2 inches in the middle of the lettuce rooting zone. Soil microbial biomass carbon was determined for the 0-to-4-inch depth. Total organic carbon and nitrogen were tested by combustion. Approximately 500 lettuce plants per sampling point were visually examined in the field for symptoms of lettuce drop disease. Mean percentage of the taproot showing cracking and yellowing characteristics of corky root disease (*Rhizomonas suberfaciens*) was

TABLE 2. Soil properties in deep minimum-tillage field before and after conventional tillage (chiseling, ripping, disking and leveling) in midwinter, 1995-1996\*

Depth (inches)	Bulk density (g/cm <sup>3</sup> )		Net mineralizable N (µg N/g dry soil)		Soil gravimetric moisture (%)	
	Sept 1995	Feb 1996	Sept 1995	Feb 1996	Sept 1995	Feb 1996
0-2.4	1.06	1.05	8.1	14.3	32.0	34.5
15.7-18.1	1.21	1.13	ND	ND	32.2	34.5

\* Means (n = 6). No significant differences were observed between September and February. ND = no data.

TABLE 3. Responses to alternative tillage practices to retain semipermanent, raised beds\*

	July 1997†			July 1998		Sept 1999		
	Shallow	Deep chisel	Shallow	Deep chisel	4-step deep till	Shallow	Deep chisel	4-step deep till
<b>Lettuce yield and disease</b>								
Fresh weight (g)	ND	ND	811a	863ab	943c	873x	939xy	967y
Dry weight (g)	21.30m	22.56 m	36.44a	37.81a	39.24a	36.46x	38.85x	39.01x
Lettuce drop (%)	6m	4m	5a	2b	1b	4x	2y	1z
Corky root (% of taproot affected)	17m	17m	56a	43b	47b	5x	4x	5x
<b>Soil microbial biomass (µg C/g<sup>1</sup> dry soil) in surface layer</b>								
0–4 inches	225m	254m	291a	233ab	182b	355x	343x	330x
<b>Soil bulk density (g/cm<sup>3</sup> dry soil) at three depths</b>								
0–2.4 inches	1.08m	1.06m	0.95a	0.98a	0.95a	0.90x	0.86x	0.99x
7.9–10.2 inches	ND	ND	ND	ND	ND	1.09xy	1.17x	0.96y
15.7–18.1 inches	1.29m	1.24m	1.19a	1.23a	1.27a	1.24x	1.14x	1.07x
<b>Soil gravimetric moisture (%) at three depths</b>								
0–2.4 inches	27.5m	29.1m	34.7a	31.2ab	33.0b	28.6x	28.0x	27.6x
7.9–10.2 inches	ND	ND	ND	ND	ND	32.9x	30.9x	30.8x
15.7–18.1 inches	30.9m	32.0m	36.1a	34.2a	33.6a	34.0x	30.5y	31.1xy
<b>Soil total organic C and N (%)</b>								
Org. C (0–4 inches)	ND	ND	ND	ND	ND	2.01x	1.94x	1.93x
Org. N (0–4 inches)	ND	ND	ND	ND	ND	0.24a	0.24a	0.22b

\* Treatments began in April 1996. Shallow = Sundance System only; deep chisel = minimum-till chisel only; 4-step deep till = 4-step deep minimum tillage. ND = no data. Means with the same letter are not significantly different. See text for sample sizes.

† Sampled prior to harvest maturity.

assessed on approximately 12 plants per sampling point dug to a depth of 7 inches. Lettuce yield was determined by weighing the fresh whole heads in a 1.2-square-yard (1-square-meter) area at each sampling point, then again after drying. Lettuce root length density was determined in September 1997, in soil cores taken at 0 to 4, 4 to 8, 8 to 12, 12 to 16, 16 to 20 and 20 to 30 inches below the soil surface. Roots were washed free of soil, and root length was measured on a root-length scanner. Treatment differences were evaluated with t-tests ( $P < 0.05$ ).

In July 1997, approximately 1 year after the treatments had begun, there were no differences in lettuce dry weight, disease symptoms, soil microbial biomass carbon, soil bulk density or gravimetric moisture between the shallow minimum tillage and minimum-till chisel treatments (table 3). Root-length distribution was also similar between treatments in all depth increments (data not shown). In this time interval, shallow

and deep methods to retain semipermanent beds had similar effects.

In 1998, lettuce fresh weight was significantly lower in both the shallow and chisel minimum-tillage treatments than with four-step deep minimum tillage (table 3). There were no differences among treatments in lettuce dry weight. A higher percentage of lettuce plants had symptoms of lettuce drop wilt in the shallow minimum-tillage treatment than either of the deeper tillage treatments. The mean percentage of the taproot showing cracking and yellowing characteristics of corky root disease was significantly higher in the shallow treatment. Soil microbial biomass carbon in the surface layer was significantly higher for both the shallow and chisel minimum-tillage treatments than with four-step deep minimum tillage. Water content at the soil surface was highest in the shallow minimum-tillage treatment, intermediate in the four-step deep minimum treatment and lowest with chisel minimum tillage, suggesting slight differences in soil physical properties. No

difference in bulk density was found among the tillage treatments.

In 1999, lettuce fresh weight was again lowest in the shallow minimum-tillage treatment, intermediate in the minimum-till chisel treatment and highest with four-step deep minimum tillage (table 3). Dry-weight differences were again not significant among treatments. Reasons for the differences in lettuce fresh- and dry-weight responses are not clear, but deserve further study. The percentage of plants with lettuce drop symptoms was higher with shallow minimum tillage than with minimum-till chisel, or with four-step deep minimum tillage. Corky root symptoms were minor, and no differences were observed, but 'Venus' is a corky root-resistant variety. Soil microbial biomass carbon was not significantly different between treatments. The cover crop in the previous winter may have contributed to higher levels and less difference between treatments compared with 1998. There were no significant differences among treatments in total organic carbon in the surface 4 inches of soil. Total organic nitrogen was significantly lower with four-step deep minimum tillage. Soil bulk density was similar among treatments at the surface and lowest depths, but was significantly lower with the four-step deep minimum tillage at the middle depth. Moisture at the lowest depth was highest for the shallow minimum-tillage treatment.

### Plant vs. soil responses

This on-farm project showed that minimum-tillage operations that include deep chiseling and ripping lead to higher fresh lettuce yield and lower symptoms of lettuce drop disease than the shallow minimum-tillage system, despite the trend toward decreased soil microbial biomass and organic matter in the surface layer when deep tillage was used. Deep tillage may bury sclerotia and thereby limit infection (UC IPM 1987). Higher yields with deep minimum tillage may be

(continued on back cover)

The following research articles, news stories and editorials appeared in *California Agriculture*, Volume 55, Numbers 1 through 6, January through December 2001; numbers are *Jan-Feb* (1), *Mar-Apr* (2), *May-June* (3), *July-Aug* (4), *Sept-Oct* (5) and *Nov-Dec* (6). Back issues may be purchased for \$4 per copy, while supplies last; make checks payable to UC Regents.

## Research articles

### Animal, avian, aquaculture & veterinary sciences

Internal parasites prevalent in California's beef cattle — Drake et al. *Mar-Apr* p28

Managing manure and conserving predators helps control flies in caged-layer poultry systems — Mullens et al. *Sept-Oct* p26

Research on animal-borne parasites and pathogens helps prevent human disease — Lane, Anderson *Nov-Dec* p13

Sheep-killing coyotes a continuing dilemma for ranchers — Timm, Connolly *Nov-Dec* p26

Sheep research offers alternatives to improve production — Price, Bradford *Nov-Dec* p19

\* Callipyge meat a tough sell — Sainz *Nov-Dec* p32

\* Is there a sire-dam interaction in sperm fertilizing potential? — Berger, Dally *Nov-Dec* p25

Targeting alphas can make coyote control more effective and socially acceptable — Jaeger et al. *Nov-Dec* p32

### Economics and public policy

Almond advertising yields net benefits to growers — Crespi, Sexton *Jan-Feb* p20

Potential economic impacts of irrigation-water reductions estimated for Sacramento Valley — Lee, Sumner, Howitt *Mar-Apr* p33

Township limits on 1,3-D will impact adjustment to methyl bromide phase-out — Carpenter, Lynch, Trout *May-June* p12

### Food and nutrition

First-grade gardeners more likely to taste vegetables — Morris, Neustadter, Zidenberg-Cherr *Jan-Feb* p43

USDA program stimulates interest in farmers' markets among low-income women — Joy et al. *May-June* p38

### Human and community development

Interpersonal communication tops concerns of farmworkers — Billikopf *Sept-Oct* p40

Numbers rising . . . Grandchildren raised by grandparents a troubling trend — Blackburn *Mar-Apr* p10

### Land, air and water sciences

Alfalfa water use pinpointed in saline, shallow water tables of Imperial Valley — Bali, Grismer, Snyder *July-Aug* p38

Insufficient spring irrigation increases abnormal splitting of pistachio nuts — Doster et al. *May-June* p28

One-pass tillage equipment outstrips conventional tillage method — Upadhyaya et al. *Sept-Oct* p44

Peach trees perform similarly despite different irrigation scheduling methods — Goldhamer et al. *Jan-Feb* p25

Reducing fertilizer in sugarbeets can protect water quality — Kaffka, Kirby, Peterson *May-June* p42

Simplified tree water status measurements can aid almond irrigation — Goldhamer, Fereres *May-June* p32

Soil properties change in no-till tomato production — Herrero et al. *Jan-Feb* p30

Sudangrass uses water at rates similar to alfalfa, depending on location — Grismer *July-Aug* p44

### Natural resources

Brush piles and mesh cages protect blue oak seedlings from animals — Weitkamp, Tietje, Vreeland *Mar-Apr* p23

Carefully timed burning can control barb goatgrass — DiTomaso et al. *Nov-Dec* p47

\* Animals and fungi can affect goatgrass establishment — Eviner, Chapin *Nov-Dec* p53

Live oak saplings survive prescribed fire and sprout — Tietje, Vreeland, Weitkamp *Mar-Apr* p18

Monitoring shows vegetation change at multiple scales — Merenlender et al. *Nov-Dec* p42

Plant species provide vital ecosystem functions for sustainable agriculture, rangeland management and restoration — Eviner, Chapin *Nov-Dec* p54

Sudden oak death syndrome fells three oak species — Garbelotto, Svihra, Rizzo *Jan-Feb* p9

\* Multi-scale approaches taken to SOD monitoring — Kelly, McPherson *Jan-Feb* p15

Survey identifies sediment sources in North Coast rangelands — Lewis et al. *July-Aug* p32

Watershed research examines rangeland management effects on water quality — Dahlgren et al. *Nov-Dec* p64

### Pest management

Armored scale insecticide resistance challenges San Joaquin Valley citrus growers — Grafton-Cardwell et al. *Sept-Oct* p20

BIOS and conventional almond orchard management compared — Bentley et al. *Sept-Oct* p12

Combining bensulide and pendimethalin controls weeds in onions — Bell, Boutwell *Jan-Feb* p35

Egg-laying and brochosome production observed in glassy-winged sharpshooter — Hix *July-Aug* p19

Host-specific strain of *Stemphylium* causes leaf spot disease of California spinach — Koike, Henderson, Butler *Sept-Oct* p31

\* Field guide: Foliar problems of California spinach — *Sept-Oct* p33

Insecticides sought to control adult glassy-winged sharpshooter — Akey, Henneberry, Toscano *July-Aug* p22

\* Field guide: How to distinguish glassy-winged sharpshooter from its "look-a-likes" — Varela *July-Aug* p12

Proximity to citrus influences Pierce's disease in Temecula Valley vineyards — Perring, Farrar, Blua *July-Aug* p13

Rust disease continues to threaten California garlic crop — Koike et al. *Sept-Oct* p35

Sampling program for grape mealybugs improves pest management — Geiger et al. *May-June* p19

### Plant sciences

Agroforestry is promising for previously cleared hardwood rangelands — McCreary *Nov-Dec* p37

Australian varieties improve pasture in long-term annual legume trials — Graves et al. *Nov-Dec* p60

New closterovirus in 'Redglobe' grape causes decline of grafted plants — Uyemoto et al. *July-Aug* p28

Table grapes suffer water loss, stem browning during cooling delays — Crisosto, Smilanick, Dokoozlian *Jan-Feb* p39

## News departments

### Editorials

Human Resources equipped to serve a dynamic California — Varcoe *Mar-Apr* p2

Methyl bromide phase-out becomes reality — Carter *May-June* p2

Research collaboration best defense against Pierce's disease — Gomes *July-Aug* p2

Research and extension reduce impact of California energy crunch — Reid, Thompson *Sept-Oct* p2

### Editorials (continued)

Sudden oak death spurs massive team effort — Gomes *Jan-Feb* p2

UC Research and Extension Centers: Statewide system provides local answers to local needs — Gomes *Nov-Dec* p3

### Hopland special issue: Introduction

Hopland celebrates 50 years of rangeland research — *Nov-Dec* p6

### Letters

— *Jan-Feb* p4; *Mar-Apr* p4; *May-June* p4; *July-Aug* p5

### Outreach news

Grandparents raising grandchildren a national concern — *Mar-Apr* p8

\* A tale of two grandmothers — *Mar-Apr* p9

Partnerships key to sustainable agriculture — *May-June* p6

### Progress reports

BIFS reports potential for chemical reductions in crops and dairy — *Sept-Oct* p10

European grapes tested in North Coast vineyards — *Nov-Dec* p10

Genetic variation data could help blue oak reseeding efforts — *Nov-Dec* p11

Suburbia aside, black-tailed deer are in decline — *Nov-Dec* p11

### Research updates

Center proposes solution for ag biotech licensing disputes — *Mar-Apr* p6

Efforts underway to prevent foot-and-mouth disease — *May-June* p8

\* Is vaccination the answer? — *May-June* p9

Exotic pest research goes high-tech — *Mar-Apr* p7

Methane generators turn agricultural waste into energy — *Sept-Oct* p9

\* UC scientists "cracking the nut" — *Sept-Oct* p9

New pest management center based at UC Davis — *Jan-Feb* p6

New tools, methods needed to replace methyl bromide — *May-June* p10

Oak killer found in rhododendrons — *Jan-Feb* p7

Scientists, state aggressively pursue Pierce's disease — *July-Aug* p8

\* Funds pour in for Pierce's disease research — *July-Aug* p9

\* Genetic research employed to fight Pierce's disease — *July-Aug* p11

\* Pierce's disease resources — *July-Aug* p8

Study reveals risk factors for teen suicide — *Sept-Oct* p5

UC scientists help growers cope with energy crunch — *Sept-Oct* p6

### Science briefs

Caught rat-handed — *Sept-Oct* p4

Genetically engineered tomato grows in salty water — *Sept-Oct* p4

"Jumping genes" aid gene delivery — *Mar-Apr* p5

Lake Tahoe clarity falls again — *May-June* p5

New biological control agent released against invasive saltcedar — *July-Aug* p7

Pesticides linked to frog decline — *May-June* p5

Scientists try to slow GWSS — *Jan-Feb* p5

SOD spreading; new research promising — *Mar-Apr* p5

### Staff changes

— *July-Aug* p4

\*Sidebars

## Lettuce tillage (continued from page 38)

partially due to lower disease, and possibly to soil physical factors. Although we did not compare yields under minimum and conventional tillage, chiseling and ripping semipermanent beds produced less soil compaction for conventionally tilled vegetable fields on two of four locations having different soil textures. Shallow minimum tillage appears to be satisfactory for short periods — between vegetable plantings, for example — as a means to reduce labor and fuel use, and

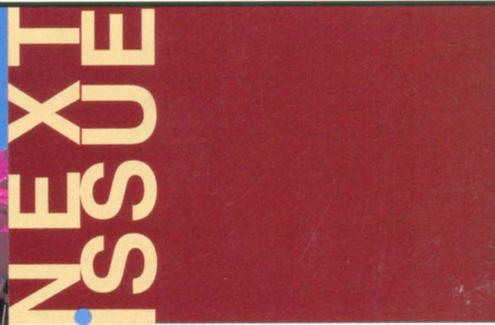
hasten the planting of a second crop during the summer.

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*L.E. Jackson is Professor and Extension Specialist, and I. R. Ramirez is Post-Graduate Researcher, Department of Vegetable Crops, UC Davis; I. Morales is Manager, Ranch One, American Farms, Chualar; and S.T. Koike is Farm Advisor, UC Cooperative Extension, Monterey County.*

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**Preparing California youth for the workforce is one of the central challenges UC faces in the 21st century. Studies consistently show that many young people currently lack the basic skills needed to succeed in today's highly technical global economy. In the next issue of *California Agriculture*, UC scientists analyze workforce preparation and career awareness among more than 1,400 high school seniors and others in Northern California and suggest ways that UC programs can best serve the needs of teenagers, whether they are bound for college or their first full-time job.**



CALAG@ucop.edu  
Phone: (510) 987-0044  
FAX: (510) 465-2659

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