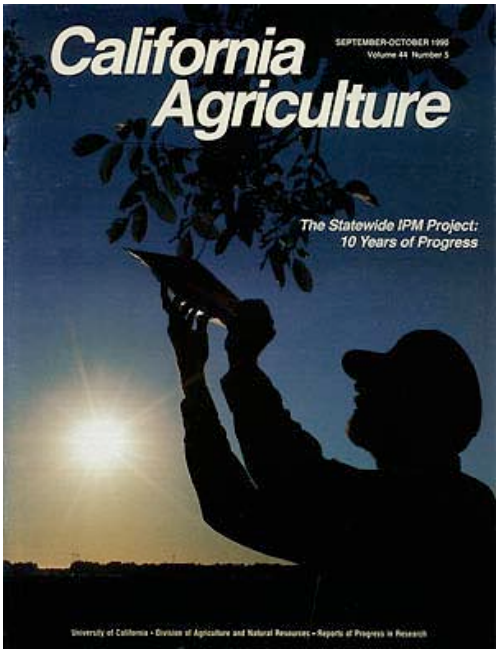
A HISTORY
OF THE
UNIVERSITY OF CALIFORNIA
STATEWIDE IPM PROGRAM

James M. Lyons

Table of Contents

IV. THE SECOND TEN YEARS AND BEYOND

July 1, 1990 to April 3, 2003



On the tenth anniversary of the Statewide IPM Project, a special issue of *California Agriculture* ("The Statewide IPM Project: 10 Years of Progress," Vol. 44 (5) Sept/Oct 1990) summarized research and extension activities over the previous decade. The Statewide IPM Project's research and extension activities were growing well as it entered its second ten years, but it was also being hit hard by budget cuts. The permanent base support for the IPM Project was reduced by over $240,000, resulting in the loss of two academic positions including an area IPM advisor; reduced supplies, equipment, and travel for IPM staff; the elimination of opportunity funds that were used for program evaluation and analysis; and a reduction of $65,000 in research grant funding. The Project began focusing on external support from state and federal agencies as well as the private sector, to obtain funds for program enhancements.

In 1992 The National Environmental Awards Council presented the program with a Certificate of Environmental Achievement and recognized it as an "outstanding program in the Renew America 1992 Environmental Success Index. "In 1994 the California Legislature passed a resolution recognizing the Statewide IPM Project's success in improving pest management and reducing pesticide use over the previous 15 years, and in 1998, the program was again presented with a Certificate of Environmental Achievement by the National Environmental Awards Council.

A Special Section of *California Agriculture*, 54:6, November-December 2000, was devoted to summarizing advances during the twenty years of the IPM Project and how IPM evolves to battle new pests as they arrive.

Organization and Administration

Although the IPM Project was well established, it underwent several significant changes following its tenth anniversary.

New Location. In March 1999, the IPM administrative office and information systems group were relocated from Wickson Hall to the Robbins Hall Annex, also in the central part of the campus. The building was extensively remodeled to make it suitable for the program.

Pesticide Education Program. In 1993, the Pesticide Education Program (later the Pesticide Safety Education Program) became a separate management unit under the leadership of Pesticide Training Coordinator Patrick O'Connor-Marer. Although housed in the same buildings as the IPM Education and Publications unit, Patrick O'Connor-Marer now reported directly to Project Director Zalom. Patrick became responsible for all study materials and educational programs related to pesticide applicators. Mary Louise Flint remained responsible for educational programs and study materials for pest control advisers.

Exotic Pests and Diseases Research Program. The UC IPM Program joined with the Center for Exotic Pest Research (CEPR) at UC Riverside to prepare a proposal for a USDA-Cooperative State Research, Education and Extension Service (CSREES) Special Research Grant. The proposal, prepared by Frank Zalom in consultation with CEPR Director Mike Rust and ANR Program Leader Joseph Morse, was successful and $1.1 million was made available for a competitive grants program in 2001-02 to address exotic pests and diseases that threaten agricultural, urban, and natural systems in California. The structure of this competitive grants program was modeled after the IPM grants program, with a request for proposals, a series of review panels, and a technical committee to recommend funding. A second grant ($1.4 million) was successful for 2002-03, and another was prepared for 2003-04 to continue the research program.

The Exotic Pests and Diseases Research Program issued its first report in 2002.

Resignation of Frank Zalom as Director, October 2001. After 14 years as IPM Project director, Frank Zalom resigned, effective October 31, 2001, to become a full time entomologist in the Entomology Department at UC Davis. Former director Jim Lyons served as interim director during the 16 months it took to recruit a new director.

A Review: Statewide Special Programs and Projects in the Pest Management Area, January 10, 2001. In 2000, ANR Associate Vice President Henry Vaux asked Jim Lyons to undertake a review of the several programs and projects that had activities in pest management. A particular focus of the review was to address how activities among the various groups could be better coordinated and whether any consolidation or reorganization would be beneficial. The report (appendix IX) was completed in January 2001, and two parts directly related to the IPM Project. One was a recommendation that an external search be conducted to replace Frank Zalom as director. This was acted upon and a new director chosen (see the section that follows).

The second item involved the potential retirement of Mike Stimmann, who was both director of the Center for Pest Management Research and Extension (CPMRE) and the statewide pesticide coordinator. The report recommended that when Mike retired, the CPMRE should also be "retired" since all of the putative duties had been essentially superceded by the reorganization of DANR that had resulted in the creation of program directors in subject matter areas, one of which was pest management. The report also recommended that when Mike retired, his responsibilities as statewide pesticide coordinator should be transferred to Rick Melnicoe, who was director of the USDA

Western Region Pest Management Center (WRPMC) that was housed on the Davis campus in the Department of Environmental Toxicology. This was to occur with a transfer of a 0.25 FTE from Mike's DANR position to Rick Melnicoe, who up to this point was totally funded by the USDA grant. It was also recommended that Rick be appointed as an assistant to the director of IPM to link the WRPMC and the IPM Program more closely. The primary function as pesticide coordinator was continued responsibility for validating pesticide recommendations embedded in UC IPM's pest management recommendations. This transfer took place in April 2002, upon Mike's retirement.

Statewide Program vs. Statewide Project. The program was initially identified as the Statewide IPM Project, but over time, it was referred to as the Statewide IPM Program as often as not. The 1994 legislative resolution identified it as a "program," as did other internal documents. The only factual difference is with the notion that "project" can have a temporary connotation, indicating that it has a finite life and will terminate when completed. "Program" reflects an ongoing effort, and hence in 2002 after 23 years, this became the uniform reference to what was once a "project."

Bylaws, November 2002. An issue that arose periodically was the question of whether research review panel (formerly "workgroup") members, and particularly panel chairs, could serve on a panel and also be principal investigator or cooperator of a proposal submitted to that panel's subject area. For a period of time the office of the vice president—ANR (OVP) allowed PIs to serve as members and chairs of review panels, but then they reversed that policy. Since this reversal greatly limited the pool of qualified scientists available (and/or willing) to serve on the panels, the OVP eventually recanted their decision and told the IPM Program that it could use whatever policy as stated in the bylaws. This led the program to recognize that bylaws had never been developed, so Interim Director Jim Lyons set out on that task, obtaining formal approval of a set of bylaws on November 1, 2002 (appendix X). These bylaws codified the program's established practices and, on the conflict of-interest issue, stated that, "if the PI or cooperator of a proposal is a member of an IPM review panel, a different panel must review the proposal. Panel chairs are eligible to submit proposals (as a PI or cooperator), however they will not be allowed to participate in the discussions related to their proposals."

Rick Roush joined UC IPM as director in 2003.

New Director. An international search for a new UC IPM director was initiated in the spring of 2001 after Frank Zalom announced his intention to resign as director, effective October 31, 2001. Jim Lyons was asked to serve again as interim director until a permanent director could be chosen. The process was completed on March 3, 2003, when Dr. Richard (Rick) Roush arrived and assumed the duties as director. Rick received his BS in entomology at UC Davis in 1976 and his PhD in biological control with Dr. Marjorie Hoy at UC Berkeley in 1979. After finishing his degree, he spent time at Mississippi Sate University and Cornell University, and most recently in Adelaide, Australia, where he was director of the Cooperative Research Centre for Weed Management.

The 1994 organizational chart (figure 7) describes the structure of the IPM Program through the end of this period.

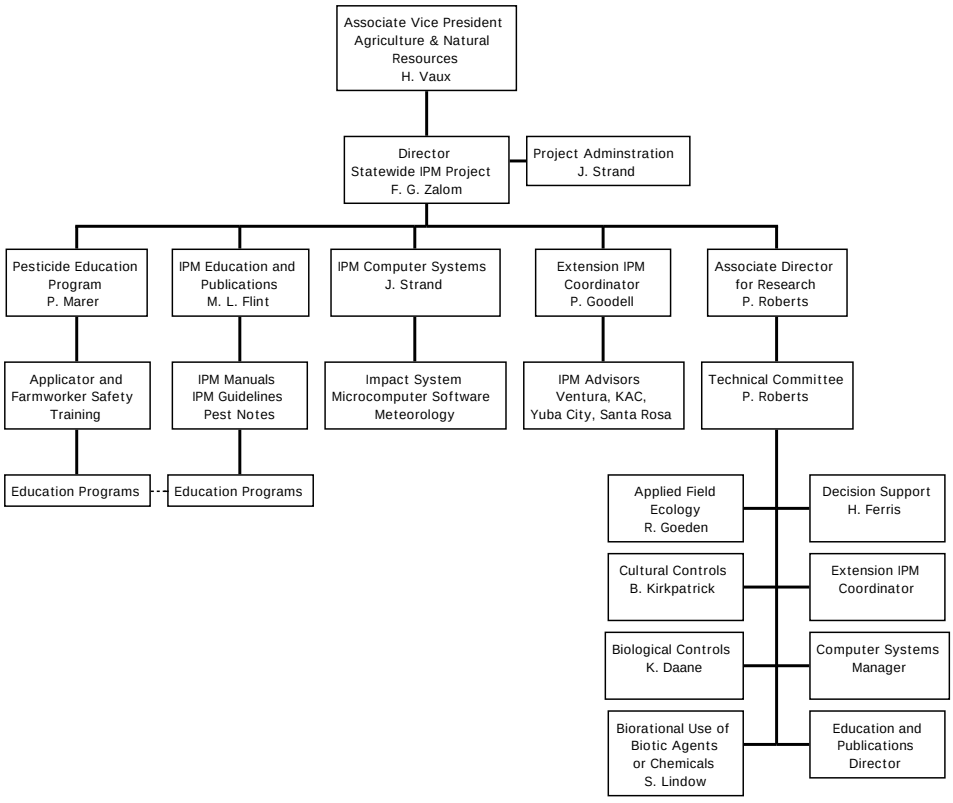


Figure 7. 1994 Statewide IPM Program Organizational Chart.

Field Implementation

Establishment of a "Core" Group at Kearney Agricultural Center (KAC). Changes in the administration of CE specialists were proposed in 1990-91 to comply with the new administrative procedures instituted within DANR by Vice President Ken Farrell. Among other changes, the new structure required that all CE FTE had to report through campuses or regions and could no longer report directly through directors of statewide special projects such as UC IPM. In order to achieve a clear understanding of reporting lines and expectations for regions/campuses hosting a position from a special project, a Memorandum of Understanding (MOU) had to be developed between the special project and a regional/county director or a dean/department chair. Such MOUs were developed for all the area IPM advisors at that time. Frank Zalom took the opportunity of this administrative change to propose that an interdisciplinary core of IPM specialists be developed at KAC to represent the four core pest management disciplines of entomology, nematology, plant pathology, and weed science. To accomplish this, Jim Stapleton, a plant pathologist, and Pete Goodell, both a nematologist and an entomologist, would be relocated to KAC. Bill Barnett, an entomologist, was already located at KAC, and a vacant FTE would be recruited as an IPM weed scientist at KAC. Four area IPM advisors would remain in county locations: Bud Beasley in Riverside, Sue Blodgett in Sonoma, Phil Phillips in Ventura, and Carolyn Pickel moving from Santa

Cruz County to fill the vacancy in Sutter-Yuba counties. It was also planned that those area IPM advisors choosing to return to the title of area IPM "specialist" could do this by aligning with a department. Pete Goodell was accepted by the Nematology Department at UC Davis and Jim Stapleton by Plant Pathology at UC Berkeley. However, realities of the budget cuts for 1990-91 made it impossible to transfer these advisor positions to specialist positions and hence the change was never instituted. The core group was assembled at KAC, but they remained area IPM advisors and reported through the regional director. Frank Zalom became a CE specialist and entomologist in the AES in the Entomology Department at UC Davis, reporting through the campus dean.

In April 1991, the core team at KAC published the first issue of "Plant Protection Quarterly," a newsletter that published reviews of pest management research and activities. Information in the newsletter targeted farm advisors and Agricultural Experiment Station researchers.

Lucia Varela explains pest identification to Spanish-speaking vineyard workers.

Other changes occurred in the area IPM advisor staffing during this period. In 1992, Sue Blodgett took a leave of absence for a year and entomologist Dr. Lucia Varela replaced her in an acting appointment. When Sue decided not to return to UC, Lucia was appointed to the position permanently. Carolyn Pickel was relocated from Santa Cruz County to Sutter County in the Sacramento Valley region. In July 1992, Dr. Tim Prather joined the group of IPM advisors at KAC. Tim's training in weed science complemented the others in the group, and he had a special interest in the use of geographical information systems (GIS) to compile maps of geography, soil conditions, weather, and cropping patterns that would make weed surveys more effective and less time consuming. In his time at KAC, Tim helped establish hands-on training in weed seedling identification for PCAs. In October 1994, Walt Bentley, an entomology farm advisor in Kern County, joined the IPM team at KAC to fill the

Weed ecologist Anil Shrestha checks a weed in a cotton field.

Walt Bentley monitors pistachio tree with beating stick and tray.

Tim Prather checks weed identification with a hand-held computer program.

position left by Bill Barnett's retirement. Dr. Cheryl Wilen joined the staff in September 1995 as area IPM advisor in the southern region, headquartered in San Diego. Her focus was on IPM for ornamental horticulture including greenhouse, nursery, and landscape situations important in the ag-urban interface. Tim Prather resigned his position with the IPM Program in 2000 to accept a faculty position in Idaho. This left a vacancy in the weed science position at KAC. Dr. Anil Shrestha joined the core group at KAC as a regional IPM advisor/weed ecologist in March 2002. Anil had several years of experience in weed management, cropping systems, and sustainable agriculture.

It is interesting to note that about the time that Tim Prather was being courted for a faculty position in Idaho, the issue of area IPM advisors becoming area IPM specialists arose again as a possible means of enticing Tim to stay in California. However, the administration resisted this change with the justification that the function of advisor was one of the key components that has allowed the California IPM program to succeed in a way no other state has been able to approach. As specialists become more involved with individual research efforts tied to a campus department, implementation activities have historically suffered.

IPM Advisor Cheryl Wilen monitors field-grown cornflowers.

Building Partnerships. In the 1990s, community-based alliances of growers, pest management professionals, and researchers began springing up throughout the state to meet the challenges of finding reduced-risk pest management approaches. In most of these alliances, Cooperative Extension provided crop, pest, and IPM expertise, while producers, pest control advisers, and other interested organizations provided pragmatic direction to research and implementation. Each alliance worked cooperatively to review the current system and develop a plan. Frequent field meetings and demonstrations were a cornerstone of every program. Throughout the process, there is an active exchange of ideas, experience, and knowledge. For most crops, these alliances truly invigorated pest management systems.

The first group to use this model was the Merced Almond BIOS (Biological Integrated Orchard Systems) in 1988, which addressed issues related to insecticide reduction, fertility management, and cover crops, and was funded by UC Sustainable Agriculture Research and Education Program. Since that time, the California Department of Pesticide Regulation has used this general model of participatory extension and research to develop a competitive grants program for pest management alliances (PMAs) directed at promoting reduced-risk practices.

UC Statewide IPM Program advisors and specialists have been leaders in developing and coordinating successful PMAs in prunes, almonds, walnuts, cotton, pears, and nurseries. Active involvement in PMAs allowed IPM advisors to enhance and multiply their extension efforts. Each program was different and measures of success vary. The cotton PMA grew out of a successful alliance of UC Cooperative Extension and industry that saw the amount of pyrethroid, carbamate, and organophosphate insecticides used in San Joaquin Valley cotton drop by almost 60% between 1995 and 1999. The prune PMA evolved through the merger of several other cooperative efforts

and strong leadership from the California Prune Board and has seen quick adoption of methods. Successful alternatives were found for all insect pests in prunes except aphids. The walnut PMA moved ahead demonstrating practical methods of using biological control for codling moth, validating a walnut blight model, and other reduced-risk practices. Each alliance not only moved the science of pest management forward, but also enhanced the extension of IPM information.

IPM Education and Publications

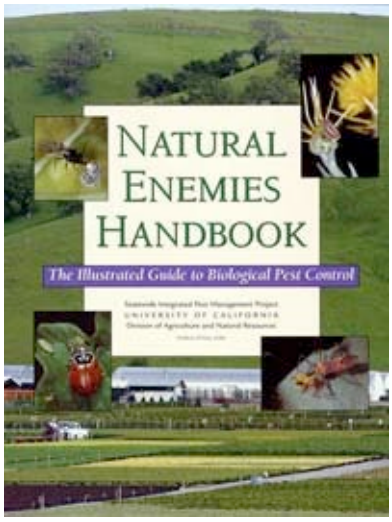
Education and Publications staff in 1997. Clockwise from left, Peg Brush, Steve Dreistadt, Larry Strand, Shawn King, Patty Gouveia, Cheryl Reynolds, Barbara Ohlendorf, and Mary Louise Flint.

In the years between 1990 and 2002, the IPM Education and Publications group continued to diversify its products and its audiences. At the beginning of the decade almost all of the group's products were produced on paper. By 2003, a substantial portion of the publications was on electronic media. The target audience grew as well. In the 1980s, almost all IPM publications were aimed at agricultural audiences. In the 1990s, IPM publications began to serve urban and suburban audiences as well.

The successful IPM manuals series continued to thrive. By 2003, there were 14 books covering 20 different crops. New titles came out on apples and pears (Ohlendorf), strawberries (Strand), stone fruits (Strand) and floriculture and nurseries (Dreistadt). Ten of the original manuals had been substantially revised as second editions. As each new book came out, the format and content improved on previous manuals. Later manuals had more photographs and larger ones, more line drawings and information on monitoring, more identification helpers, indexes, and more comprehensive bibliographies. Average length of the manuals went from 96 pages in the 1980s to over 200 pages in 2000. Almost 100,000 copies of these manuals had been sold. They had become a standard item in every PCA's bookshelf.

New books were produced to address the pest management needs of California's growing urban and suburban population. *Pests of the Garden and Small Farm*, published first in 1991 and revised in 1998 as a second edition (Flint), provided home gardeners and organic growers with IPM information for growing fruits and vegetables with low toxicity inputs. It included a diagnostic reference table of problems on 30 different fruit and vegetable crops. *Pests of Landscape Trees and Shrubs* (Dreistadt), released in 1994, was modeled after the *Pests of the Garden and Small Farm* format and addressed pest problems and IPM solutions on ornamental trees and shrubs. This book was extremely popular and became a study guide for several professional certification programs, including those for arborists and nurserymen. Both of these books became standard references for UC's master gardener programs; a great impetus for writing them was the lack of reliable research-based resources available for these volunteers who provide much of UC's outreach to urban audiences.

The Natural Enemies Handbook: An Illustrated Guide to Biological Control (Flint and Dreistadt) was released in 1998. This attractive publication, co-published by ANR Communications Services and UC Press, was selected by Choice Magazine as one of the Outstanding Academic titles of 1999, received the Silver Medal from the Agricultural Communicators in Education Association, and was honored as a faculty author selection at the UC Davis Faculty Authors Celebration 1998. It served a student as well as a practitioner and garden audience.



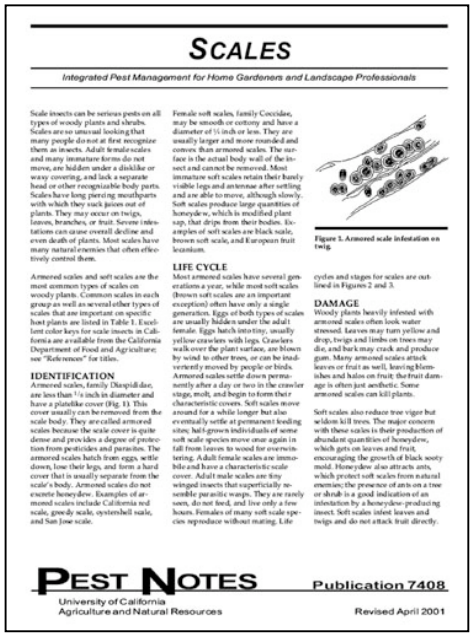
A number of other smaller publications were produced during this decade. These included *Managing Insects and Mites with Spray Oils* (1991), *Color Photo Guides for Sugarbeet Pests, Dry Bean Pests and Onion/Garlic Pests* (1995 and 1996). Other titles were *Whiteflies in California: A Resource for Cooperative Extension* (1995), *Reducing Insecticide Use and Energy Costs in Citrus Pest Management* (1992), and *The Natural Enemies Poster*. All of these are now available as ANR Communication Services publications.

Compiling and updating the *UC IPM Pest Management Guidelines* for agricultural crops continued to be an important task for the IPM Education and Publications group in the 1990s. By 2003, PMGs had been written for 43 individual crops or crop groups. In 1995, a major joint project with the UC IPM computer systems group was putting the PMGs on the UC IPM Web site. For all of the PMGs, staff identified hyperlinks to photos to illustrate pests, pest damage, natural enemies, and management techniques. As hyperlink editor for a group of PMGs, each senior writer continues to add new photographs as guidelines undergo major revisions (usually on a three-year schedule). These links and illustrations have made the guidelines more useful on the Web site. Many changes occurred in the dissemination of the PMGs, which were first primarily in paper format produced in PageMaker. Later they were produced as Word files only and placed on the Web as HTML and PDF formats. The PMG production staff (Shawn King, Peg Brush, and Barbara Ohlendorf) had to work very closely with the computer systems staff to develop protocols to interface paper and electronic production, and many innovative solutions were devised. The subscription offered by ANR Communication Services for the PMGs ended in 2000.

The weed photo gallery was introduced in 1998. The text is compiled by IPM Education and Publications staff and photos selected from the UC IPM photo collection. Weed scientist Joe DiTomaso reviews text and photos for all new weed galleries. By 2003, more than 150 weed species were covered. In 2003 a similar photo gallery for natural enemies was initiated.

A major project in the late 1990s was the development of a study guide and exam questions for pest control advisers to incorporate more IPM concepts. The impetus for this project came from the PCA organizations that were frustrated at outdated study material and exams that did not reflect current pest management technologies. Working with committees of experts from the University and the private sector, Patricia Gouveia (hired in 1995) and Mary Louise Flint developed knowledge expectations for all PCA licensing areas that detailed what PCAs should be expected to know to be licensed. Study guides were identified in most of the licensing areas that could address these knowledge expectations, and a special IPM textbook, *IPM in Practice: Principles and Methods of*

Integrated Pest Management was written to clearly outline integrated pest management concepts, methods, and tools. This book was released in 2001 and became a standard IPM text for many colleges. Pools of exam questions that addressed each of the identified knowledge expectations were written for each area. This involved consultation with experts from within the University and the private sector for all seven licensing areas and for IPM. Final exam questions for all areas were submitted to California Department of Pesticide Regulation (CDPR) in 2003, and new exams were initiated by CDPR that year. Emily Thacher Blanco came on board in 2001 to finish up exam questions and format them in LXR software, which allows them to be easily evaluated and tracked by CDPR. This project of upgrading the licensing exams took six years and involved more than 100 people.


SCALES

Integrated Pest Management for Home Gardeners and Landscape Professionals

Scale insects can be serious pests on all types of woody plants and shrubs. Scales are so unusual looking that many people do not at first recognize them as insects. Adult female scales and many immature forms do not move, and lack a distinct head or other recognizable body parts. Scales have long piercing mouthparts with which they suck juices out of plants. They may occur on twigs, leaves, branches, or fruit. Severe infestations can cause overall decline and even death of plants. Most scales have many natural enemies that often effectively control them.

Armored scales and soft scales are the most common types of scales on woody plants. Common scales in each group as well as several other types of scales that are important on specific host plants are listed in Table 1. Excellent color keys for scale insects in California are available from the California Department of Food and Agriculture; see "References" for titles.

IDENTIFICATION

Armored scales, family Diaspididae, are less than ⅛ inch in diameter and have a platelike cover (Fig. 1). This cover usually can be removed from the scale body. They are called armored scales because the scale cover is quite dense and provides a degree of protection from pesticides and parasites. The armored scales hatch from eggs, settle down, lose their legs, and form a hard cover but is usually separate from the scale's body. Armored scales do not excrete honeydew. Examples of armored scales include California red scale, greedy scale, oystershell scale, and San Jose scale.

Female soft scales, family Coccidae, may be smooth or cottony and have a diameter of ⅛ inch or less. They are usually larger and more rounded and convex than armored scales. The surface is the actual body wall of the insect and cannot be removed. Most immature soft scales retain their barely visible legs and antennae after settling and are able to move, although slowly. Soft scales produce large quantities of honeydew, which is modified plant sap, that drips from their bodies. Examples of soft scales are black scale, brown soft scale, and European fruit lecanium.

LIFE CYCLE

Most armored scales have several generations a year, while most soft scales (brown soft scales are an important exception) often have only a single generation. Eggs of both types of scales are usually hidden under the adult female. Eggs hatch into tiny, usually yellow crawlers with legs. Crawlers walk over the plant surface, are blown by wind to other trees, or can be inadvertently moved by people or birds. Armored scales settle down permanently after a day or two in the crawler stage, molt, and begin to form their characteristic covers. Soft scales move around for a while longer but also eventually settle at permanent feeding sites; half-grown individuals of some soft scale species move once again in fall from leaves to wood for overwintering. Adult female scales are immobile and have a characteristic scale cover. Adult male scales are tiny winged insects that superficially resemble parasitic wasps. They are rarely seen, do not feed, and live only a few hours. Females of many soft scale species reproduce without mating. Life cycles and stages for scales are outlined in Figures 2 and 3.

DAMAGE

Woody plants heavily infested with armored scales often look water stressed. Leaves may turn yellow and drop, twigs and limbs on trees may die, and bark may crack and produce gum. Many armored scales attack leaves or fruit as well, leaving blemishes and halos on fruit; the fruit damage is often just aesthetic. Some armored scales can kill plants.

Soft scales also reduce tree vigor but seldom kill trees. The major concern with these scales is their production of abundant quantities of honeydew, which gets on leaves and fruit, encouraging the growth of black sooty mold. Honeydew also attracts ants, which protect soft scales from natural enemies; the presence of ants on a tree or shrub is a good indication of an infestation by a honeydew-producing insect. Soft scales infest leaves and twigs and do not attack fruit directly.

Figure 1. Armored scale infestation on twig.

PEST NOTES Publication 7408

University of California Agriculture and Natural Resources

Revised April 2001

The Pest Note series of short answer pest management publications for home, garden, and landscape was launched in 1995. At this time, UC had almost no short answer publications for this audience and few people in the system willing to write them. The series was first set up as camera-ready publications with line drawings so county UC CE offices could photocopy them and give them out for free. With the development of the UC IPM Web site, they quickly also became online publications with hyperlinked color photographs. By 2003, Pest Notes for 109 different pests, including arthropods, weeds, pathogens, and vertebrates, were available and several others were under production.

Cheryl Weber Reynolds was hired in 1995 to assist in the production of the UC IPM Program's first interactive CD-ROM. This was a joint project with Mary Lou Flint, Joyce Strand, and Pam Geisel of UC CE Fresno. *The UC Guide to Solving Garden and Landscape Problems* was released in early 2000. It contained more than 2000 screens and 4800 photographs to help gardeners and landscapers identify over 600 pests and disorders. A second CD-ROM, *The UC Guide to Biological Control* written by Mary Lou and Cheryl, was released in 2002. A third CD-ROM on managing snails and slugs was created and released as a limited-edition training tool.

By 2001, the program decided to focus on using the Web for interactive educational tools rather than CD-ROMs. Several new products were produced on the UC IPM Web site. The IPM and water quality part of the site was created to meet a real need by master gardeners and local agencies to answer residential queries about pesticides and water quality and how to reduce impacts. An interactive key to household ants was produced and placed on the Web site in 2001. An interactive guide to lawn care, the "UC Guide to Healthy Lawns," was first placed on the

Web in 2002 and was expanded in 2003. A special training session for master gardener coordinators was held in March 2003 to train them how to use interactive tools and information sources on the Web.

The IPM Education and Publications office became involved in several educational programs related to urban use of pesticides and water quality. The group worked with the City of Modesto to create information cards for residents of that city in 2000. Also, in a more extensive project with the City and County of Sacramento, staff created a series of consumer pest cards that informed residents about alternatives to organophosphate insecticides. These cards eventually became the statewide consumer pest cards used by many county offices and master gardener programs and the Quick Tips on the UC IPM Web site in both English and Spanish. Jodi Azulai joined the IPM Education and Publications staff in 2000 to help coordinate a training program for master gardeners in Sacramento County on water quality and IPM. This program was very successful, and several other county programs adopted the binder and related educational materials. The program was recognized with a CDPR IPM Innovator Award in 2001 and will serve as a starting point for future programs.

During the 1990-2003 period, staff was involved in a number of educational programs to extend information found in their publications. After the release of *Pests of Landscape Trees and Shrubs*, Steve Dreistadt and Mary Louise Flint, along with Patrick O'Connor-Marer, organized a series of statewide conferences to promote the concepts and techniques presented in the book. The programs were held in public arboretums so hands-on activities and diagnostic tours could be incorporated. Since 2000, Mary Louise and Steve organized and co-sponsored the California Association of Nurseries and Garden Centers CCNPro Education Days for retail nursery professionals. The UC IPM Program also organized and sponsored a conference for public agencies in March 2002, to promote networking between UC scientists and public agency personnel who were charged with carrying out IPM programs in parks, schools, playgrounds, and public buildings. Staff members were also closely involved with the IPM for Schools program coordinated by CDPR, including participating in pilot training programs and working with the CDPR staff to create an interface between UC IPM's Pest Notes and their pesticide hazard information in the IPMHELPR.

Pesticide Safety Education Program

PSEP staff in 1997. Clockwise from left, Kathy Garvey, Pat O'Connor-Marer, Melanie Zavala, Jenny Weber, Diane Clarke, and Gale Perez.

The UC IPM Pesticide Safety Education Program (PSEP) was begun in 1988. It assumed responsibility for developing study materials and educational programs for California's pesticide handlers and pesticide safety information for individuals who work in areas where pesticides are used. In 2002, there were about 26,000 certified commercial applicators, 40,000 certified private applicators, and more than 70,000 non-certified mixer-loader-applicators in California. In addition, nearly 1,000,000 agricultural workers labor in fields that may have been treated with pesticides. State and federal laws mandate training for anyone working with pesticides or working in areas where pesticides have been applied. In

2002, Pesticide Safety Education Program staff included a coordinator (Patrick O'Connor-Marer), two bilingual pesticide educators (Jennifer Weber and Tim Stock), a meeting planner (Gale Perez), a writer (Diane Clarke), an administrative assistant (Rosa Rossiter), and a 0.3 FTE evaluation specialist (Sonja Brodt). Former staff, including writers Mark Grimes and Kathy Garvey, contributed to developing study guides for commercial pesticide applicators. Bilingual pesticide educators Melanie Zavala and Guadalupe Sandoval developed many of the Spanish-language training materials and pioneered both the hands-on workshops and the statewide train-the-trainer programs. Research and outreach grants and income from program activities provided support for most of these positions. The Pesticide Safety Education Program became an integral part of the NIOSH-funded Western Center for Agricultural Health and Safety, and O'Connor-Marer served as deputy director for the Center.

Since the program began, staff wrote and published more than 6,200 pages of information on ways to reduce risks when applying pesticides and how to handle and use these materials safely and legally. Publications include 11 study manuals for certified applicators, 14 instructor manuals for people who train pesticide handlers and agricultural fieldworkers, and 18 informational manuals and pamphlets for employers. In addition, staff produced 10 pesticide safety videos and two training games, and contributed many articles to trade publications and technical journals. Many of the program publications are available in Spanish and others have been translated into Japanese and Punjabi. Several of the study manuals are used as textbooks in various states and some were translated into other languages for use in Cuba, South America, Southeast Asia, Russia, and the United Arab Emirates. The program also became involved in several research projects to develop and test effective ways to bridge language, cultural, and educational barriers when extending pesticide health and safety information to California's workforce. One successful project involved using English-as-a-second-language (ESL) and English-for-specific-purposes (ESP) concepts to help Hispanic and Hmong farmers read and understand pesticide labels.

PSEP produced this publication in Spanish in 1991, and updated it in 1998.

The program offered ongoing train-the-trainer workshops throughout California each year for employers, labor contractors, and others responsible for training pesticide handlers and agricultural fieldworkers. The program also conducted annual workshops throughout the state for health care providers, supplying them with much-needed information on recognizing and managing pesticide poisoning. Program staff pioneered hands-on workshops for training pesticide handlers in the early 1990s, a concept adopted by community groups in several counties. Program staff presented information on pesticide-use risk reduction at more than 50 county Cooperative Extension educational meetings and master gardener training programs each year. Staff members were often asked to assist farm advisors in training Spanish-speaking farmworkers on ways to avoid exposure to pesticide residues.

Computer Systems

Throughout the 1980s and 1990s, UC IPM added new resources to its computer system and enhanced others, but use of the system was limited by the difficulty users had with the technology for connecting to the online system. However, when the World Wide Web entered onto the scene in the mid-1990s, computer manufacturers, software producers, and telecommunications providers provided streamlined systems to jump the connection hurdle. With the technology factor removed as an issue, UC IPM was well-situated to take advantage of the Web as a much-improved distribution system. The program had been building computerized IPM content for almost 15 years, and was ready to rework that information to incorporate the advanced features of the Web.

In 1995, the computer group began converting its primary resources from the IMPACT computer to the World Wide Web, and the process was completed in 1996. Immediately, UC IPM's Web site (www.ipm.ucdavis.edu) was the most content-rich site available for pest management. Through the Web, UC IPM could be reached by anyone in the world looking for the information provided there and information could be linked with other documents and sites with useful information on related subjects. Pest management guidelines and other documents could be illustrated with color photos and line drawings to help readers identify pests or understand how IPM methods worked.

Work on databases and software in support of the University's statewide pest management extension and applied research programs continues. Products have been designed to improve information delivery, research, and education by county extension offices, and to be used in the testing of research findings and delivery to the public and private sectors. Almost all software and databases are written for the Web. This allows new versions to be distributed easily and supports Unix, Macintosh, and PC platforms with little extra effort.

Advice to Growers, Landscapers, and Residential Users. Particularly after the move to the World Wide Web, the information systems group worked closely with the IPM Education and Publications unit to develop online materials for farmers, residential users, and landscapers. The original Web site, opened in October 1995, featured the *UC IPM Pest Management Guidelines*, UC's recommended alternatives for controlling pests on crops, commercial turf, and in homes and landscapes. In contrast to the printed version or the earlier IMPACT computer version, the Web guidelines could be illustrated with high-quality color photos of the pest's life stages and its damage, which added greatly to the usefulness of the materials.

Over time, materials were added to help readers better identify pests and beneficial organisms. The weed photo gallery contains descriptions and photos of more than 125 weeds commonly found in California farms and landscapes. The natural enemies gallery gives photos, descriptions, and some information about the targets of the beneficial organisms. Interactive keys, including a key to common household ant species and keys to various aphids, have also been developed. Additional landscape and garden materials include an interactive "UC Guide to Healthy Lawns" and a set of pages describing the effects of home pesticide use on water quality. These materials are lavishly illustrated and prepared designed to be not only informative but to grab the viewer's attention.

A number of resources were developed in cooperation with researchers to help growers make better decisions when managing their crops. Some examples:

- Degree-day calculator that, along with weather data from IPM's extensive database or a grower's own station, lets growers and PCAs time pesticide sprays better.
- Cotton planting forecasts, made daily during planting season, help growers know when conditions are right to get a good stand of cotton.
- Dormant spray alternatives calculator to help stone fruit and almond growers determine costs of alternatives to dormant organophosphate sprays.
- Silverleaf whitefly resistance monitoring update for the desert valleys.
- Processing tomato weather network postings of disease severity calculations for blackmold
- Index of risk of grape powdery mildew infection posted daily.

California PestCast. In 1995, U.S. EPA gave a grant to UC IPM to develop a public-private weather network in support of crop-disease model research validation and outreach to encourage adoption of these models for improved disease management. Through partnerships with industry, networks were established in Mendocino, Lake, Fresno, Madera, Santa Cruz, and San Joaquin counties, and a tomato network reached from Fresno County through the southern Sacramento Valley. These, and a few individual stations, supported disease model validation projects on 15 projects on 11 crops. The effort built on an earlier cooperative project between UC IPM, Extension Plant Pathologist Doug Gubler, Adcon Telemetry, and growers in Napa, Sonoma, and Kern counties to validate and implement Gubler's grape powdery mildew model.

PestCast weather station in a tomato field.

Pesticide Information. With funding from USDA-Extension Service, the computer group developed a database that summarized the pesticide use reports from CDPR by site, chemical, county, and month. The database provided the first opportunity for individuals to access the pesticide use data gathered in response to the 100% reporting requirement that went into effect January 1, 1990. Each year's data was added as it became available from DPR, and by 2001 the database summarized 39 million records for years 1990 through 2000.

Crop and Pest Models. CALEX/Cotton, a project funded through the IPM grants program, was an expert system designed to help growers manage several aspects of cotton production, such as fertilizer, irrigation, and pests. The information systems group worked with the large CALEX team of research and extension scientists to develop the program as a saleable product. UC IPM first distributed the computer program in 1988, and during each of the next three years, staff revised it to add new information developed in the field. CALEX/Cotton was a first attempt to bring together information on the interactions among the various management tasks related to growing cotton to help growers make better decisions. The program wasn't a commercial success, but it served as an integrating tool; in building the program, researchers were able to see how practices fit together, how much was being required of growers or pest control advisers, and the need for new tools to streamline data gathering for decision making related to cotton.

Through the Web site, users have access to interactive models of about 20 specific pests and to a database that describes models of crops, insects and mites, nematodes, weeds, and diseases, as reported in the scientific literature.

UC IPM Program Information. The Web site distributes descriptive materials about the IPM Program and its publications, workshops, and other resources. It contains the UC IPM annual reports, descriptive materials about program activities, and a database describing all projects funded through the UC IPM competitive grants program and the Exotic Pests and Diseases Research Program.

Research Grants Program

Chairs of the Technical Committee. Chairs of this committee that oversaw the grants process during these years were:

1990-92	Joseph Morse	Entomology, UC Riverside
1992-96	Philip Roberts	Nematology, UC Riverside
1996-99	John Menge	Plant Pathology, UC Riverside
1999-2002	Michael Rust	Entomology, UC Riverside

Review of the Research Grants Program

In 1991, the Technical Committee reviewed the existing workgroups and priorities to determine if they reflected the strategies and tactics that could most efficiently be applied toward meeting the stated goals of the IPM Program. As a result of this review, the biological controls and the cultural controls workgroups would continue with only minor changes in priorities. A new workgroup for the biorational use of biotic agents or chemicals was recommended, which reflected the potential for improving and applying pest control alternatives such as microbial agents, attractants, and repellents. Another new workgroup, applied field ecology, would focus on interactions between pests, their hosts, biotic factors that regulate their abundance and the abiotic environment. A new workgroup for decision support would focus on development of tools that would assist pest managers in more efficiently monitoring or predicting crop and pest status. These new workgroups replaced the previous workgroups on commodity-pest interactions, monitoring systems, and systems application.

In November 1994, Frank Zalom undertook an external review of the research program, designed to define the agenda for the IPM Project for the subsequent five years. This review, by an *ad hoc* IPM research program advisory committee, was to set parameters for research proposals that would be submitted by potential investigators. At a meeting held on the Davis Campus on October 27, 1994, 26 individuals who represented a diverse cross section of grower groups, agencies, and related organizations (see appendix VIII) were invited to meet with the IPM Technical Committee to discuss the structure of the grants program and current priority research areas. The review committee indicated that the existing workgroup structure was adequate to address priority research needs. However, it recommended that some mechanism be established such that growers, PCAs, and others could have input into prioritizing projects to be funded. The breakout groups assigned rankings to the general research areas, identifying weed management and postharvest pests as the most significant areas that should receive more emphasis. Resistance management, economic and environmental evaluation, and roadside weed control were rated lowest of the priority areas identified.

As a result of the *ad hoc* committee's recommendations Frank reported back (see appendix VIII) that the Project would take the following actions: report to the DANR administration about the committee's concerns that additional pest management research emphasis was needed in the areas or weed (vegetation) management and postharvest pests and recommend that DANR consider additional staffing for the study of both weed management and postharvest pests; emphasize these research areas in its request for proposals to ensure an understanding that research proposals in these areas were both appropriate and welcome; and solicit from commodity groups and other interested organizations a list of priority concerns for pest management research and the reasons for their concerns as a meaningful approach to obtaining external input into the grants process. When UC IPM conducted a survey of 54 commodity groups and organizations, 24 responded. These identified almost 250 individual issues related to about 30 crops or specific sites, and 150 invertebrate, disease, weed, and vertebrate pests.

A Profile of IPM Research Results from 1989-1999. Karen Klonsky and Ben Shouse surveyed principal investigators funded under the UC IPM Competitive Grants Program to examine the evolution of the IPM Project from 1989 through 1999 (*California Agriculture* 54:6, pages 20-21, 2000). Survey respondents helped characterize the distribution of grants by commodity area and discipline, the degree of collaboration fostered, research goals, and outcomes of research.

The following is taken from the *California Agriculture* article:

> In the last decade, almost half of the projects funded involved fruit, nut, or vegetable crops, and another quarter addressed field crops. The remaining projects focused on livestock, nursery and flower crops, and urban or landscape pests, or did not specify a commodity, focusing instead on general techniques. In all, 194 funded research projects investigated 45 different crops. By contrast, during the Project's first 10 years, it focused 80% of research funding on eight major crops or commodities (alfalfa, citrus, tomatoes, cotton, rice, grapes, walnuts, and cereals).
>
> *Collaboration.* Klonsky and Shouse's data was based on completed surveys from 78% of the principal investigators to whom surveys were mailed, representing 153 of the 194 projects that

received IPM grants between 1989 and 1999.

Entomology was the discipline most often included in the research projects (45%), followed by plant pathology (21%). Most (70%) were managed by two or more investigators. While only 17 projects (9%) involved principal investigators from different academic disciplines, 49 projects (25%) involved principal investigators from different institutions (table 1)**.** The rates of interdisciplinary cooperation and cross-institutional studies were lower than during the first 10 years of the program, when rates of 38% and 36% respectively, were identified (Grieshop and Pence 1990). From these results, it appears that collaboration of principal investigators is more likely to occur within disciplines, but across institutions as researchers look beyond their own institutions to find co-investigators with the necessary technical expertise and interests to develop IPM research proposals. Principal investigators reported receiving assistance from a variety of cooperators (table 2). Notable among these were UC farm advisors, who were the most frequent participants of any group in every stage of the research process except providing field trial space. They were seldom principal investigators on proposals although they were essential collaborators in developing proposals, managing field trials, and collecting data.

Growers participated in the research projects either as individuals or through commodity groups. Field-trial space was provided by growers for well over half of the IPM Projects, and these growers assisted in managing almost one-third of those field trials. Clearly, the generous support of growers is critical to the research program funded by the UC IPM Program. However, growers were much less likely to be involved in data collection or interpretation of the results than in other aspects of the research either as individuals or through a commodity group.

Of other individuals and organizations outside of UC, representatives of commodity groups were twice as likely as growers, public agencies, or state-licensed PCAs to be involved in research proposal development, but none of these groups participated in more than 10% of proposals in terms of field trial management, data collection, or interpretation of results.

Research Outcomes. The principal investigators responding said research outcomes included publications, pest-control methods and equipment, and computer decision aids. About two-thirds of the UC IPM research projects resulted in 480 publications, of which 220 appeared in peer-reviewed journals. Web-based publications emerged from 10% of the projects. Virtually unknown 10 years ago, Web dissemination of information will undoubtedly continue to expand in the coming years.

While 30% of the projects resulted in nonchemical pest-control procedures, less than 10% developed synthetic chemical pest-control procedures, reflecting the general goal of UC IPM to develop strategies and tactics that permit pest managers and growers to move away from the use of synthetic pesticides toward biorational materials and other risk-reducing approaches. Developing decision-making protocols and sampling procedures continue to be important goals of IPM research.

Fewer resources were directed toward developing computer programs for clientele than in the

first 10 years of the program. This may reflect increasing sophistication of the general public in using software such as spreadsheets for their own decision making, increased use of the Web, and an increase in software development by the private sector.

Pest Control Methods Developed. During the 1990s, the USDA's National Agricultural Statistics Service began to classify growers' approaches to pest control as prevention, avoidance, monitoring, and suppression, and this has become one tool for measuring IPM adoption. Preventative measures act to decrease the likelihood of an infestation through techniques such as using pest-free planting material, sanitation of equipment to avoid spreading weed seeds, destroying overwintering habitat for insects, and irrigation scheduling to avoid disease infestations. Avoiding exposure to pests means planting resistant varieties, crop rotation to break pest cycles, and choosing locations that are relatively pest-free. Suppression includes methods used in response to a pest outbreak to avoid reaching economically damaging levels. Monitoring is typically used in conjunction with suppression methods for information used in making the control decision.

Most of the research projects (77%) included pest suppression as a method of pest control and 40% focused solely on pest suppression (Table 3). The most common suppression method investigated was biocontrol/natural enemies (38% of projects), followed by chemical pesticides (14%) and organically acceptable microbial and botanical pesticides (13%). Over one-third of the projects developed monitoring procedures. One-fifth of the projects focused on avoidance practices such as use of resistant cultivars in an IPM program, crop rotation, timing of harvest, and trap crops, while one-fifth focused upon cultural practices used to prevent infestations.

Research Goals. Klonsky and Shouse's analysis did not measure the adoption of IPM techniques, but rather documented the goals of the researchers. In many cases, the projects had multiple goals. Almost three-quarters of the projects were directed toward reducing pesticide use, and two-thirds of the projects were undertaken to improve the efficacy of pest control. Other frequently mentioned goals were lowering the cost of pest control, increasing the social acceptability of pest control systems, increasing the use of natural controls, and providing pest management methods for organic production. In particular, 39% of the projects developed methods appropriate for organic production.

The regulatory atmosphere that has evolved over the last decade to emphasize soft (environmentally benign) *and* risk-reducing approaches is a reflection of society's continuing concern for environmental and health impacts of continued use of broad-spectrum synthetic pesticides. IPM research hopefully will help growers and pest managers meet challenges posed by issues such as the Food Quality Protection Act, loss of methyl bromide, the Clean Water Act's Total Maximum Daily Load Program, and, of course, profitability.

A challenge of the UC IPM Competitive Grants Program over the next 10 years will be to set priorities that will enable the development of practical soft and risk-reducing approaches that can be implemented by farmers and other pest control practitioners in California.

Cited Reference
Grieshop JI, Pence RA. 1990. Research results: Statewide IPM's first 10 years. *Cal Ag* 44(5): 24-6.

Table 1. Distribution of IPM Projects by Principal Investigators' Institutional Affiliation

Institution	Funded Projects (n=194)		Survey Response (n=153)	
	Number	%	Number	%
Cross-institution*	49	25	40	26
UC Davis	60	31	48	31
UC Riverside	41	21	36	24
UC Berkeley	32	17	20	13
Cooperative Extension	4	2	3	2
Statewide IPM Project	7	4	5	3
USDA	1	1	1	1

*Defined as more than one UC campus or Cooperative Extension office and more than one academic department on the same campus.

Table 2. Assistance Provided by Institutions and Individuals at Various Stages of the Research Process (n = 153)

Persons Assisting	Develop Research Proposal	Provide Field Trial Space	Manage Field Trial	Collect Data	Interpret Results
Growers	20 (10)*	106 (55)	51 (26)	13 (7)	10 (5)
Commodity groups	41 (21)	7 (4)	9 (5)	3 (2)	5 (3)
Agencies	16 (8)	8 (4)	8 (4)	7 (4)	7 (4)
PCAs	23 (12)	15 (8)	17 (9)	9 (5)	5 (3)
Farm advisors	75 (39)	37 (19)	56 (29)	50 (26)	43 (22)
IPM advisors	22 (11)	6 (3)	13 (7)	13 (7)	14 (7)
Faculty	54 (28)	10 (5)	12 (6)	20 (10)	42 (22)
CE specialists	42 (22)	4 (2)	12 (6)	21 (11)	30 (15)
UC IPM staff	3 (2)	1 (1)	0 (0)	2 (1)	5 (3)

*Numbers in parentheses are percents of total number of projects.

Table 3. Methods of Pest Control Developed by IPM Research Projects

Methods of pest control	Projects	
	Number	%
Prevention	30	19
Avoidance	31	20
Monitoring	52	34
Suppression:	119*	77
Natural enemies/biocontrol	59	38
Chemical pesticide	22	14

Microbial pesticide	17	11

Table 3. Continued.

Physical control (e.g., barriers, flooding, burning)	16	10
Spot/precision application	16	10
Reduced-risk pesticide	13	8
Cultivation and related techniques	11	7
Adjustment of planting density	4	3
Botanical pesticide	3	2
Mating disruption	3	2
Antibiotics	1	1
Genetic engineering	1	1
Other	8	5

*Column entries and total do not match due to multiple responses.

UC IPM Publications

A complete list of publications from the UC IPM Program is in appendix XIII.