A HISTORY
OF THE
UNIVERSITY OF CALIFORNIA
STATEWIDE IPM PROGRAM

James M. Lyons

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III. TRANSITION

July 1, 1986 to June 30, 1990

The year 1986 saw a transition from a commodity-based process for deciding on research funding to an IPM "area of research" basis. Because so few IPM programs were available at the start of the IPM Project in 1979, the original structure concentrated research efforts on six crops (with three more added later) so substantial results could be achieved in a few years. Commodities were chosen either because they were major users of pesticides or because preliminary IPM programs were already available. In 1979-80, research was funded in alfalfa hay, cotton, and grapes; funding for almonds, citrus, and walnuts began in 1981; tomatoes were added in 1982, and cereals and rice in 1983.

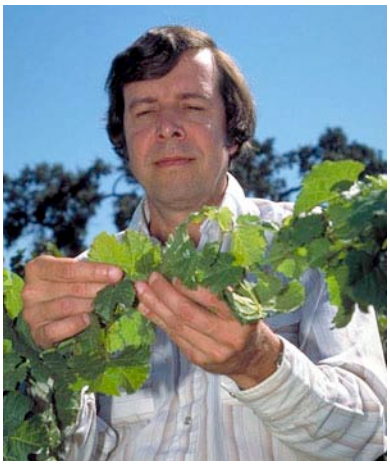
As the Project went on and goals were met, other commodities demanded that they be included in the process, but it was also clear that those currently being funded did not want to withdraw. Over a period of time, the IPM Project Technical Committee discussed the problem and recommended that modifications in the research review procedures be studied. Jim Lyons suggested that a possible solution was to have a two-step process whereby there would be a review by the existing CE commodity workgroups and a review by a set of "functional" IPM workgroups. Following these discussions, Jim Lyons appointed a small review committee to examine this issue. Mary Louise Flint chaired the committee that included Ivan Thomason, Ted Wilson, and Frank Zalom. As part of that process, Frank Zalom organized a meeting where AES researchers and CE pest management specialists met in a facilitated setting to determine the areas of IPM research that were particularly important to pursue. The entire group prioritized the research areas, and at the end of the meeting, functional IPM workgroups were identified and priorities of the workgroups set as a result of these recommendations. These recommendations were included in a May 1986 report of the committee, approved by Vice President Kendrick in July.

As a result of this process, the IPM commodity workgroups were replaced with six workgroups representing areas of research that cut across all commodities and pest management situations. Designated workgroup areas were

- Commodity-Pest Interactions
- Cultural Controls
- Biological Controls
- Systems Applications
- Monitoring Systems
- Implementation and Evaluation of IPM Programs

Organization and Administration

In July of 1987, Frank Zalom was asked to be acting director of the Project through December 3, replacing Jim Lyons who was to become the director of the newly mandated Center for Pest Management Research and Extension. On July 1, 1988, Frank was named director of the Project. He had served as associate director for research during 1986 and 1987, in addition to his duties as



Director Frank Zalom examines grape leaves.

extension IPM coordinator. When Frank became director, Joseph Morse, Entomology, UC Riverside, was appointed associate director for research. This restored the practice of having the associate director for research appointed from a campus other than the one on which the Project was housed. In 1989 the associate director for research also began to serve as the chair of the Technical Committee.

With the reorganization of the UC Division of Agriculture and Natural Resources (formerly the Division of Agricultural Sciences) in 1988, the Project assumed several new responsibilities, including: management of the USDA Smith-Lever funds for extension IPM demonstration programs and pesticide safety training of pest control applicators, pest control advisers, and farmworkers. The pesticide safety training responsibilities were consolidated within the IPM Education and Publications unit (formerly the IPM manual group) and Patrick O'Connor-Marer, was named pesticide training coordinator in 1988.

Pete Goodell took on the job of extension IPM coordinator in 1989.

In 1989 when Peter Goodell, area IPM advisor in the southern San Joaquin Valley, took on the additional responsibility of Extension IPM Coordinator, which had been held by Frank Zalom since the inception of the Project. The coordinator duties involved reviewing the group's programs and progress, coordinating the IPM Project’s needs with local demands, developing a unit affirmative action plan, developing focus projects reflecting UC-sponsored research, and serving as the extension IPM contact with federal extension programs. The 1986 organizational chart (figure 5) describes the structure of the Project at the beginning of this period, and the 1988 chart (figure 6), the structure at the end.

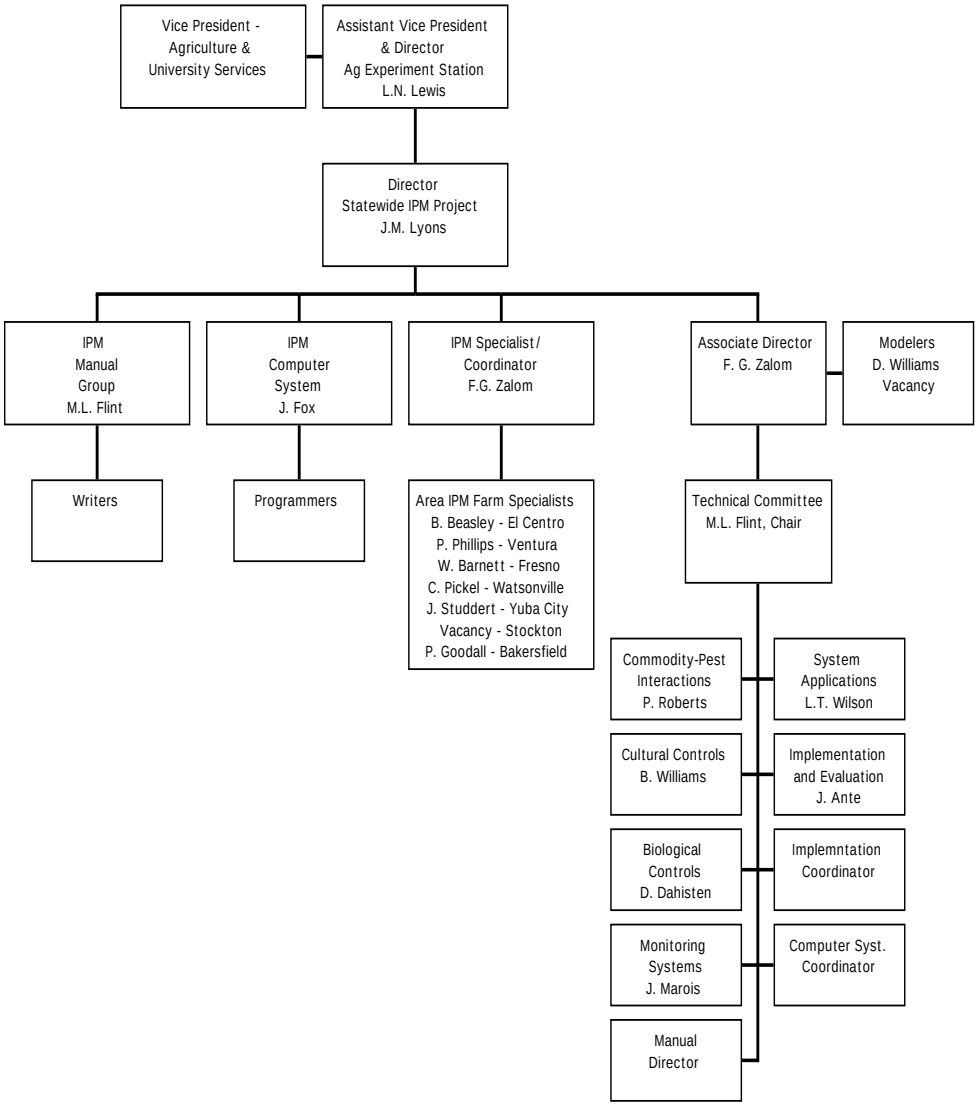


Figure 5. 1986 Statewide IPM Project Organizational Chart.

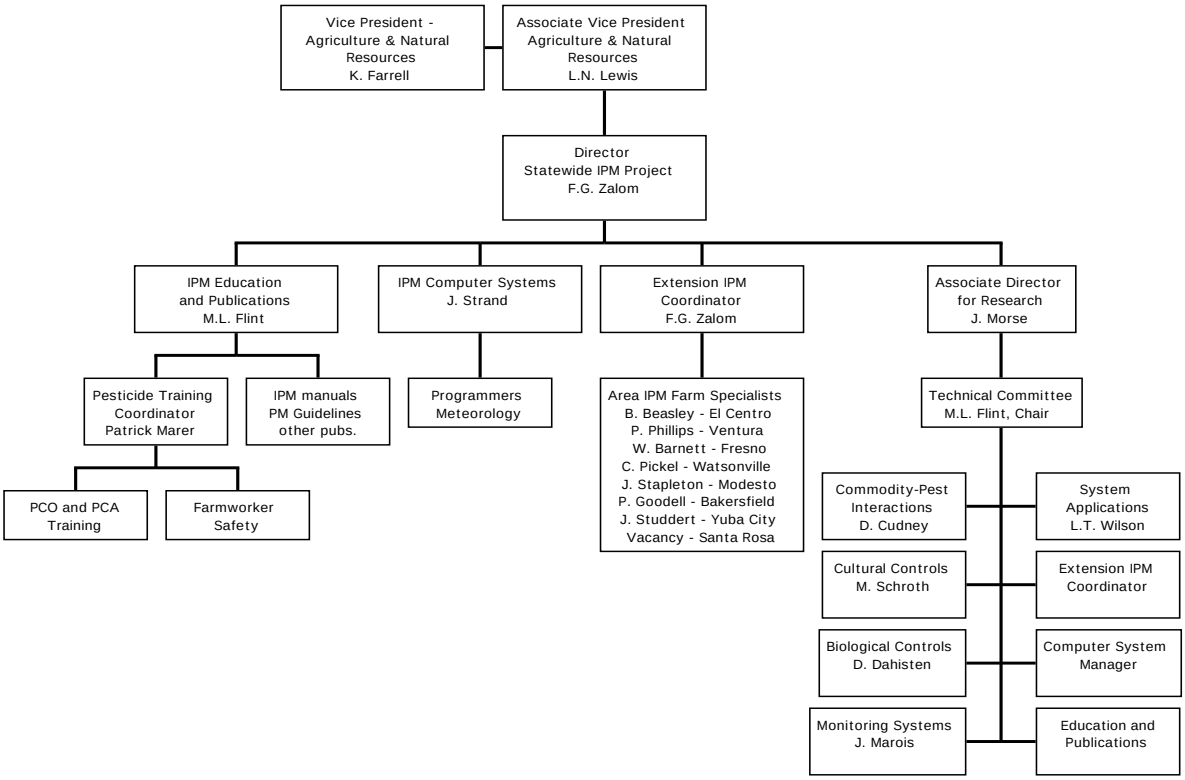
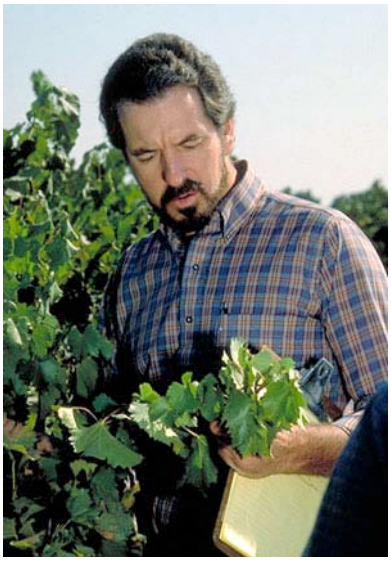


Figure 6. 1988 Statewide IPM Project Organizational Chart.

Field Implementation



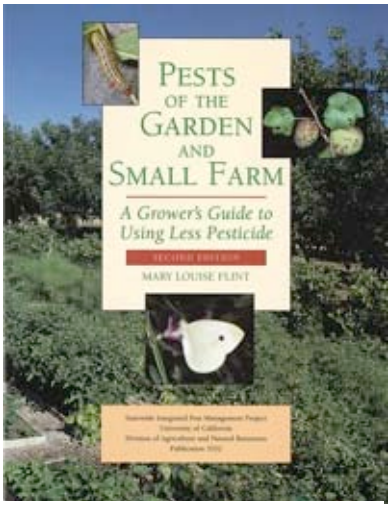
Area IPM Advisor Jim Stapleton joined the IPM Project in 1986.

Several personnel changes occurred in 1986. In August, John Studdert filled the vacant area IPM advisor position for the Sacramento Valley. The northern San Joaquin Valley position became vacant when Phil McNally left to take a research and development position in private industry. Bill Barnett, area IPM advisor in the central San Joaquin Valley, moved to the UC Kearney Agricultural Center at Parlier, and Bud Beasley, area IPM advisor in the desert valleys moved to the Riverside County CE office. Jim Stapleton was named to fill the vacancy in the northern San Joaquin Valley. Jim had a PhD in plant pathology, with a special interest in alternatives to pesticides, and had done extensive work in the controlling pathogens with soil solarization. In 1989, Sue Blodgett, an entomologist, joined the program as an area IPM advisor for the north coast region, based in the Sonoma County CE office in Santa Rosa to work on grapes, apples, and pears. Pete Goodell, area IPM advisor in the southern San Joaquin Valley, undertook the additional responsibility of extension IPM coordinator, now that Frank Zalom was director of the Project.

IPM Educations and Publications

The IPM manuals group (renamed IPM Education and Publications in 1988) took over many new responsibilities in the years 1986 to 1990. During the first five years of the UC IPM Project, the primary emphasis was on the development of IPM manuals for major agricultural crops, but during this period its activities diversified, and the group, still directed by Mary Louise Flint, became involved in a number of other projects related to communicating pest management information.

IPM Manuals and Books. By 1990, IPM manuals for nine agricultural crops had been produced. The Project released new ones on potatoes and small grains in the 1987 to 90 period and revised five previously published manuals. Keeping IPM manuals up to date started to become a major task for the group. Dr. Steve Dreistadt, an entomologist from UC Berkeley, joined the IPM Education and Publications staff as a senior writer in 1989 to revise the citrus IPM manual and to later write a book on landscape pests. June 1990 brought publication of a new manual, *Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticides*, targeted at a new audience for the IPM Project: home gardeners and small-scale, diversified organic farmers.



Pests of the Garden and Small Farm was published in 1990 and revised in 1998.

Pest Management Guidelines. A new publication series, the UC IPM Pest Management Guidelines (PMGs) was established in 1986. These were brief, but comprehensive, descriptions of management options for all pests on a specific crop that could be made available via the IMPACT computer system and free through a desktop publishing format in the county UC CE offices. A major goal of this effort was to make the guidelines more timely and easier to access, as well as easier to update. Because unlike the IPM manuals, the PMGs would be rapidly updated, they could include pesticide suggestions. The University had stopped providing pest control guidelines and pesticide recommendations for most crops in the 1970s, and there was a strong demand for this information. The new PMGs included, however, not only pesticide suggestions, but also nonchemical management techniques, monitoring guidelines, and brief information on biology and identification.

Unlike the IPM manuals, PMGs were authored by UC CE specialists, farm advisors, or faculty, but were formatted, revised, and edited by IPM manual staff. The first of the PMGs was on almonds. This was developed at a meeting Frank Zalom organized in the Merced County CE office and which included all the pest management specialists and advisors who worked on almonds. At that meeting, the first draft of what would be included in the guidelines was produced. The IPM manual staff edited this draft, formatted it, and established the pattern for subsequent guidelines. Rod Adamchak was hired in 1986 to work on the PMG project, and Barbara Peterson Ohlendorf took over as Pest Management Guidelines Coordinator in 1988. Margaret Brush was hired as an editorial assistant (later assistant editor) to do desktop publishing. By 1990, guidelines for 20 different crops had been completed. Most of the guidelines had been updated once or more as pesticide registrations or management recommendations changed. The rapidly updated guidelines were a good complement to the more durable IPM manuals. In addition to being available on the IMPACT

computer system and via photocopying from the UC CE county offices, UC ANR Publications sold the whole set and updates through an annual subscription. They became a standard reference for PCAs and farm advisors.

Other Publications. The IPM Project initiated a series of special free publications in 1984 with a publication on *Managing Mites in Almonds: An Integrated Approach* by Marjory Hoy. By the end of 1990, eleven special UC IPM Publications had been produced. Several additional titles were added in the early 1990s. These publications are listed in appendix XIII. Several eventually were published as UC Agriculture and Natural Resources (ANR) publications and the series ceased in the mid-1990s, when it became easier to publish through the Division's publication house.

Interactive Diagnostic Systems. In 1987, IPM Education and Publications staff (especially Rod Adamchak, Larry Strand, and Mary Lou Flint) began to develop an interactive diagnostic system for cotton pests using a laser disc, a videodisc player, and computer. They also developed an interactive program for weed identification. About 5,000 slides from the UC IPM photo collection were put on laser discs in anticipation of this new technology. Few people acquired the necessary equipment to use these programs in the field, but they were demonstrated at grower and PCA meetings, to students, and at CE meetings. Early experience with this technology contributed to the Project's rapid adoption of the interactive CD-ROM technology that appeared in the 1990s.

Pest Management Photo Library. In the course of preparing IPM manuals, the Pesticide Application Compendium, and other publications, the IPM Project collected a library of high-quality photographs of pests, pest damage, natural enemies, and pest management techniques; Jack Kelly Clark, under the supervision of IPM manual staff, took most of the photographs. By 1990, the collection included more than 10,000 images and IPM Education and Publications initiated a system of coding and cataloging slides in a database on the IPM computer system for easy access. The slide collection became a highly valued resource used by many within UC ANR for images for publications and presentations.

Pesticide Application Compendium Series. In 1986, the IPM manuals group took on the responsibility for creating study guides for people preparing for pesticide applicator licensing exams. The first volume of the series, *The Safe and Effective Use of Pesticides*, compiled by Patrick O'Connor-Marer in cooperation with dozens of experts both within and outside the University, was published in 1988. Work began on a second volume in the series, *Residential, Industrial, and Institutional Pest Control*, which was released in 1991. In addition, Patrick was given responsibilities as the Pesticide Training Coordinator in 1988.

Farmworker Safety Training. Melanie Zavala joined the IPM Education and Publications group in 1988 as Farmworker Safety Coordinator, working under Patrick O'Connor-Marer's supervision. Melanie had previously worked with Mike Stimmann in the Office of Pesticide Information and Coordination (OPIC) as the farmworker safety training coordinator and served as a resource to farm advisors in the area of pesticide safety training for farmworkers. Melanie

developed several pesticide safety training videos and innovative bilingual educational products during her term with the UC IPM Project.

Continuing Education Programs for Pest Management Professionals. In 1988, PCA Seminar Coordinator Shirley Humphrey was transferred to the IPM Educations and Publications Group. Patrick O'Connor-Marer, with cooperation from others in the IPM program and UC CE, set up a series of continuing education programs for PCAs and applicators. Gale Chun (later Perez) took over from Shirley Humphrey as meeting coordinator in 1989. The continuing education program for pest control advisers featured an annual statewide education theme that was repeated at about eight locations throughout the state, and included additional local topics. These seminars, held during the years 1988-89, 1989-90, 1990-91, and 1991-92, and 1993-94, were very successful, drawing in about 1,500 attendees a year. Continuing education programs for pesticide applicators were initiated in 1988-89, but the presentation style was radically changed in 1990 to feature a hands-on format.

Computer Systems

Within IMPACT the most-used resources at this time were the UC pest management guidelines database and the weather database. Available crop and pest models were also widely used to provide learning tools and management information for farm advisors, PCAs, and growers.

Programs for microcomputers in production or nearing completion at this time included a codling moth model, models of insect pests of stone fruits and of vegetables, and a trap data management program useful for researchers or practitioners monitoring insects with traps. The Division began developing policy and procedures for distribution of this kind of software outside the University.

After UC IPM opened the IMPACT system to non-UC users, Joyce Fox Strand trained PCAs and growers to use the IPM Project’s computer programs.

The Project reconfigured and upgraded the original distributed computer system. All components of the new system were located in the IPM computer facility at UC Davis. Since there was no longer a district computer at Kearney Agricultural Center (KAC, formerly Kearney Horticultural Field Station) to oversee, UC IPM and KAC agreed to transfer the programmer FTE, filled by John Rasmussen, to KAC for their local computer support. Ann Strawn at UC Riverside continued to work on developing computer representations of research results, eventually relocating to join the Davis group.

Research Grants Program

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

1986-88	Mary Louise Flint	IPM Manuals Group, UC Davis
1988-90	Joseph Morse	Entomology, UC Riverside

The research-area workgroups (described above) were established in fall 1986. Each consisted of six individuals having expertise in the particular research area and appointed by the Project director for three-year, rotating terms. They included representatives from the Agricultural Experiment Station and Cooperative Extension and from the various pest management disciplinary areas. The chair of each functional group was appointed by the Project director and served on the Technical Committee; membership is shown in appendix XI.

During the fall of 1986, the new IPM workgroups met to establish minimum criteria and priorities for funding in their research areas. All funded proposals were expected to meet minimum criteria and address one or more of the IPM Project's general goals. Established priorities helped the workgroups determine which proposals to recommend for funding, given limited monetary resources. The Technical Committee made its final recommendations after reviewing proposals from all workgroup areas. Final funding decisions were made by the Project director. Progress reports on funded research were submitted annually and reviewed by the workgroups for evaluation of progress toward meeting stated goals.

Although the IPM Project disbanded its commodity workgroups, the Project kept strong links to commodity-oriented researchers by working closely with the existing Division of Agriculture and Natural Resources (DANR, formerly Division of Agricultural Sciences) workgroups. A workgroup or a designated subcommittee of the workgroup reviewed all research proposals related to its commodity and provided written evaluations for scientific merit and importance to the commodity for each. Workgroup chairs presented their highest-ranked proposals to the Technical Committee for consideration for funding. ANR workgroups could be used to meet the research needs of their commodity as well as the goals of the IPM Project. UC IPM shared annual progress reports with commodity workgroups to keep them informed about projects funded in their commodity.

This reorganization of the IPM Project research grants program had many benefits. By involving individuals and groups outside the original nine IPM commodities, the Project was infused with new enthusiasm and new ideas. The new procedures allowed funding in commodities with very limited acreage but with great potential for IPM implementation. The new workgroups reinforced the Project's interest in areas such as biological control, implementation, and evaluation, for which the Project received fewer proposals than desirable in the past. Proposals received more critical technical reviews in the research-area workgroups, especially in areas such as systems analysis, economics, and biological control, where expertise was limited in many of the IPM commodity groups.

IPM Internship Program

An internship program for graduate and undergraduate students was also established in 1987-88. The purpose of the program was to provide educational opportunities and field management experience to students interested in IPM. Motivating students to do field research, improving training in the design of agricultural experimentation, and introducing students to the type of work cooperative extension personnel were also special goals of the program. Each student had to be sponsored by a UC CE advisor or specialist or a member of the UC Agricultural Experiment Station. A small committee was established to review these proposals and make recommendations for funding.

Three internships were funded in 1987-88. These projects and their sponsors were

- Field Evaluation of a Presence/Absence Sequential Sample Plan for Pink Bollworm Eggs in Cotton. Sponsor: Bud Beasley, Area IPM Advisor, Riverside.
- Evaluation of the Effects of Insecticides on Beneficial Parasites in Manure Communities on Caged-Layer Poultry Facilities. Sponsor: Brad Mullens, Entomology, UC Riverside.
- The Effect of Soil pH on the Biological Control of Ring Nematode and Bacterial Canker of Stone Fruits. Sponsors: Bruce Jaffee and Howard Ferris, Nematology, UC Davis.

The internship program funded four additional internships in 1988-89. No internships were funded in 1989-90, but the program resumed for two years in 1991-93 through a gift from Lucky Stores.

Research Accomplishments of the First Decade

The University of California Statewide IPM Project was created by legislative mandate in July 1979 to implement and accelerate research and extension activities in integrated pest management in the state. By January 1980, an administrative structure had been established, 27 research proposals had been funded, and staffing for the Project had begun. Over the next decade, 222 research projects were funded in over 35 different commodities or pest management situations. Research projects funded during the first decade are listed in UC IPM Publication 10, *Bibliography of Research, 1980-1990*, available from IPM Education and Publications.

As the first decade drew to a close, the IPM Project commissioned James Grieshop and Robert Pence of the Department of Applied Behavioral Sciences, UC Davis to provide an independent evaluation of accomplishments and impacts of UC IPM-funded research. To conduct their evaluation, Grieshop and Pence sent questionnaires to the 229 individuals who had been principal investigators on UC IPM-funded research between 1979 and 1988 (a total of 180 projects). Surveys queried principal investigators about the interdisciplinary nature of proposal research design, useful products or information produced, including publications, and any evidence they might have indicating that results of their research were being used by practitioners in the field. Surveys were returned by 73% of the principal investigators, representing 90% of all 180 funded projects. A report of their findings is published in Grieshop, J. I. and R. A. Pence, "A sketch of 10 years of integrated pest management research outcomes," *California Agriculture* 44(5): September-October 1990. Much of the information presented here is taken from that article or directly from the surveys themselves.

Fostering Interdisciplinary Research. An important early goal of the Project was to foster an ecological systems approach to pest management research. The original IPM Project research review workgroups addressed specific crops and were comprised of individuals from the various pest management and horticultural sciences who worked on these crops throughout the state. These workgroups provided a mechanism for interdisciplinary discussion and an impetus for numerous new working relationships. Nearly two of every five projects involved researchers from two different agricultural science disciplines and two or more different institutions. Over half of all investigators involved CE farm advisors to assist in evaluation of the practical usefulness of the proposed research and 65% involved farm advisors in implementation, suggesting further interdisciplinary bridges.

Research Products. The ultimate goal of IPM research is to develop information, techniques, devices, or other products that are useful to practitioners in the field. Table 1 lists products identified by principal investigators as having resulted from their research. In all, 91% of the responding projects laid claim to an identifiable product. Not all of these research products were yet in the hands of practitioners, however. Forty-three percent stated that their products were currently being used by PCAs and growers. Many of the others stated that the research provided a basis for conducting subsequent research (55%) or obtaining subsequent funding (32%). Presumably this further research would lead to practitioner-oriented products sometime in the future.

Table 1. Products Categorized by Research Products.

	Projects	
Product/Information	**Number**	**Percentage**
Published papers	138	77
Refereed journal papers	104	58
Data bases	61	39
Decision-making procedures	59	37
Nonchemical pest control procedures	56	35
Sampling procedures	49	31
Computer programs	31	19
Chemical pest control procedures	21	13
Equipment	12	8

Publications. Over 75% of funded projects produced some sort of publication; many of those that didn't were projects that were just getting started or still under way. Principal investigators responding to the survey listed 578 publications, including 104 refereed journal articles as well as popular press articles, extension bulletins, and book chapters. Citations for publications resulting wholly or in part from UC IPM funded research are listed in UC IPM Publication 10, *Bibliography of Research, 1980-1990,* available from IPM Education and Publications at UC Davis.

Nonchemical Pest Control Procedures. Over the decade, the IPM Project focused substantial effort toward developing nonpesticidal management methods for pests. Numbers of projects directly aimed at such cultural and biological control alternatives increased dramatically in the second five years, especially in the area of biological control. For instance, two biological control projects were funded in 1980-81, 3 in 1984-85, 7 in 1987-88, 11 in 1989-90, and 19 in 1990-91. Of 52 projects funded for 1990-91, 34 were in the nonchemical control areas of cultural controls or biological controls. Many of these projects were too recent to be part of the survey or had not yet yielded products. Even so, surveyed PIs identified 56 nonchemical pest control procedures resulting from

their IPM-funded research. Table 2 lists those that were being used at the time of the survey by at least some California growers.

Table 2. Nonchemical Pest Control Methods Developed or Improved through UC IPM Project Funded Research and Currently Being Used by Some California Growers.

Fruit and Nut Trees, Berries, and Vines
Biological control of greenhouse thrips in avocado. Biological control of citrus thrips with *phytoseiid* mites. Biological control of citrus mites. Skirt pruning for management of Phytophthora brown rot in citrus. Predators to control spider mites in various tree and vine crops including use of pesticide resistant strains. Sanitation practices for navel orangeworm management in almond orchards. Water management practices for reducing damage by mites in almonds. Ground cover management practices that impact pest management in almond orchards. Managing cover crops to reduce navel orangeworm overwintering survival in almond orchards. Frequent irrigation cuts nematode damage in half in stone fruit. Vine canopy management for Botrytis bunch rot control in grapes. Vineyard canopy management practices for mites, leafhoppers, pathogens, and other pests of wine grapes in San Joaquin Valley. Granulosis virus for biological control of Western grapeleaf skeletonizer. Blackberry refuges to encourage biological control of the grape leafhopper. Irrigation guidelines to reduce losses in Central Valley vineyards. Hot water treatment of plants for foliar nematode on strawberries.
Vegetable Crops
Use of tomato resistance and tolerance for management of nematode pests. Effect of cover crops and nitrogen on lettuce corky root. Biological control of the tomato fruitworm and beet armyworm within fields of processing tomatoes. Biological control for leafminer in fresh market tomatoes. Effects of overirrigation and water stress on Phytophthora root rot of tomatoes. Release of natural enemies for the biological control of the southern green stink bug.
Field Crops
Weed control in establishing alfalfa stands through use of an oat companion crop. Evaluation of plant resistance for root knot nematode management in alfalfa roots. Water management alternatives for reducing damage in alfalfa. Development and evaluation of genetic materials and strategies to control foliar and crown diseases of alfalfa. Integrating water depth effects on weed management in rice. Identification of insect and fungal parasites important in control of aphids in cereals. Identification of fungus disease and insect parasites important in controlling aphids in sugarbeets in California. Revitalization of disease-free regions, planting times, and other cultural controls for beet yellows virus management. Cultural control of pink bollworm with crop rotation in cotton.

Table 2. Continued.

Other
Leafminer parasites for control of the leafminer on commercially grown chrysanthemums.
Biological control of crown gall in California nurseries.
Cultural control of ground squirrels through burrow destruction.

Sampling and Decision-Making Procedures. To make better pest management decisions, growers and pest control advisers need research-based guidelines that tell them when actions must be taken to prevent unacceptable pest damage. Fifty-nine projects contributed to the development of decision-making procedures, some of which were already in field use at survey time. These decision-making procedures are listed in Table 3.

Table 3. Decision-Making Procedures Developed Wholly or Partially through UC IPM Funded Research.

Fruit and Nut Trees, Berries and Vines
Forecasting shot hole disease on almonds.
Management guidelines for navel orangeworms and webspinning mites in almond orchards.
Treatment thresholds for spider mites in almonds and grapes using spider mite day units.
Treatment thresholds for citrus thrips based on percent infestation and scarring of fruit.
When to apply pesticide for control of California red scale.
Management guidelines for Phytophthora root rot and citrus nematode infestations in citrus.
Treatment thresholds for citrus red mite.
Economic injury levels for California red scale for southern California coastal and interior and San Joaquin Valley citrus using pheromone monitoring techniques.
Guidelines for increasing reliance on biocontrols with predaceous mites in citrus.
Degree-day models for Washington navel orange growth.
Management guidelines for omnivorous leafroller and orange tortrix in grapes.
Treatment thresholds for spider mites in grapes using spider mite day units.
Determine scab infection period for apple and pear scab management.
Management decision rules for apple pests including leafhoppers and aphids.
Role of ring nematode in preventing bacterial canker complex in stone fruit.
When to control X-disease insect vector in cherry and peach.
Management guidelines for foliar nematode on strawberries.
Guidelines for management of walnut blight.
Livestock
What time of year and which drug to use on intestinal worms in beef cattle.
Choosing insecticides to minimize impact on beneficial parasites in manure communities of cagelayer poultry.
Poultry IPM scouting program for cage-layer facilities.*

Table 3. Continued.

Vegetable Crops
Comparison of natural and pesticidal control of *Bernisia tabaci* in cantaloupe fields for the reduction of lettuce infections yellows virus.
Treatment levels for tomato pinworms on fresh market fruit.
Management guidelines for leafminers in fresh market tomatoes.
Damage thresholds for tomato fruitworms and beet armyworm in processing tomatoes.
Treatment threshold for tomato fruitworm incorporating parasitization of eggs by *TrIchogramma*.
Disease thresholds for yield loss due to Phytophthora root rot of tomatoes.
Guidelines for using plant resistance and tolerance for nematode management in tomatoes.

Reducing Pesticide Use. One goal of the IPM Project has been to reduce the pesticide load on the environment. Many projects focused on development of biological information or computer models and thus indirectly addressed this goal. However, many others, especially those listed under the research areas of biological control, cultural controls, and monitoring systems, would lead to reduced pesticide use. Of those surveyed by Grieshop and Pence in 1989, 57 projects, or 36%, stated they had evidence for pesticide reduction as a result of their IPM-funded research. Table 4 shows principal investigators' perceptions of the effect of their research on pesticide use. The 1989 UC IPM Annual Report focused on reducing pesticide use, and examples of projects that reduced pesticide use are detailed there.

Table 4. IPM Research Projects Categorized by Effect on Pesticide Use Reported by Principal Investigator.

	Projects	
Effect on Pesticide Use	**Number**	**%**
Reduction	57	36
No effect	37	23
Unknown	48	30
Research still in progress	15	9

Specialized Field Sampling Techniques. Many pests require development of specialized field sampling or monitoring techniques or laboratory procedures before pest managers can assess their identity, population levels, or potential severity in the field. Twenty-eight such techniques and procedures were developed through IPM-funded research. Development of sampling procedures often goes hand-in-hand with the development of decision-making guidelines. Most of the already-developed decision-making and sampling procedures were for use in the nine commodities that were the focus of IPM Project research in the first seven years of its existence; however, by 1989, similar techniques were under development for such diverse commodities as street trees, poultry houses, nursery crops, forests, and wooden structures.

Computer Programs. The IPM Project had sponsored the development of a number of computer programs to assist in making pest management decisions. In 1989 most of these were being developed for personal computers so that practitioners could use them in their day-to-day decision making. A number were released and were available from the IPM Project. Others were more research-oriented models designed to help researchers better

understand the complex ecosystems in which pest problems arise. A few were educational models that could be used to illustrate the dynamics of pest management decision-making to students. Table 5 lists computer programs developed through UC IPM research.

Table 5. Pest Management Computer Programs Developed through UC IPM Research

WHEAT: A model for predicting wheat growth stages. TOMDAT & TOMSIN: Tomato plant phenology models. CALEYICOTTON: Cotton crop management software programs. MINGROW: Model for managing leafminer on commercially grown chrysanthemums. GPM: General population model on IMPACT for simulation of citrus pests. DDU: Degree-day utility software. ALFALFA: Alfalfa growth and development model. SIMETEO: Stochastic weather simulation for IPM. CARICE: A rice growth model. GRAPE: Model for analysis and integration of plant growth and associated pests. NOW program: Navel orangeworm computer simulation.
Cereal and wild oat phenology and growth model. Flower phenology model for Washington navel oranges and California red scale. Belding ground squirrel control educational model. Development of weed population dynamics model for barnyardgrass and other weeds. Walnut tree phenology model. CALEX/PEACH: An expert system for diagnosing peach disorders. DD-MAPPER: A climate matching model. CALEX/STONEFRUIT: A model for spider mite management in stone fruit and almonds. Crop growth and development model for processing tomatoes. Fruitworm and beet armyworm linked models for processing tomatoes. Preliminary almond bloom and fruit phenology model.

* Those followed by (*) were still in research phase and not yet in field use in 1989. Principal investigators indicated the rest were being used by commercial growers or pest control advisers in California.