A HISTORY
OF THE
UNIVERSITY OF CALIFORNIA
STATEWIDE IPM PROGRAM

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II. THE FORMATIVE YEARS

July 1, 1980 to June 30, 1986

Organization and Administration

IPM Project Technical Committee meeting in March 1982. From left, Al Grigarick, Howard Ferris, Ivan Thomason, Andy Gutierrez, and John Baritelle.

Ivan Thomason returned from sabbatical and took over as director of the Statewide Integrated Pest Management Project on July 1, 1980. Jim Lyons remained in the Project as associate director for industry and government relations. Andy Gutierrez continued as associate director for science and technical development.

The Project underwent two structural changes in the early period. The Policy Advisory Committee (PAC), originally written into the legislation because some environmental and consumer groups remained suspicious of the University's intent and ability to free itself from the influence of the pesticide industry that had been embedded in the Division of Agricultural Sciences' administration, met for a second time on October 30, 1980. The University had some apprehension about having public members involved in its programs, but once the public members had the opportunity to learn about the program and see how it was operated, they became some of its best advocates. One way this support was demonstrated was that the Project's budget was soon incorporated into the Division's regular budget and no longer viewed as a separate, limited-life package. A second, related event was that the PAC expressed the opinion that the program had developed according to plan, and because of the regular involvement of CDFA and USDA scientists in its committees and decision process, there was no need for their committee to continue. No further meetings were called.

During 1980, the Project director had to provide a report to the Legislature. Item 361 of the 1980 Conference Committee's Supplemental Report on the Budget Bill recommended that: "UC shall, not later than December 15, 1980, submit a report to the legislative budget committees updating the reports and plans regarding integrated pest management which were submitted to various legislative committees pursuant to the supplemental language of Item 346.1 of the Budget Act of 1979."

The 1979 Supplemental Language required two reports, as follows:

1) The University of California (UC) shall include at least one representative of the Director of Food and Agriculture on the policy and technical committees which are charged with making policy and funding recommendations to the Project director and the Vice President for Agricultural Services.

UC shall prepare a multi-year work plan to guide research relating to integrated pest management. UC shall allocate any funds made available by the Legislature for integrated pest management in accordance with the priorities and criteria set forth in the plan.

In preparing the plan, the UC shall familiarize itself with the environmental assessment of pesticide use and regulations completed by the Department of Food and Agriculture in 1979 and shall, insofar as they are completed, address the actions recommended in that report in its research program plan. The UC shall, further, familiarize itself with the process by which the Resources Secretary is currently reviewing state pesticide regulations for their environmental protection sufficiency and shall, in the research program plan, address any issues identified in that process to the extent they relate to integrated pest management and to the extent that this process is completed.

The UC will, in preparation of the plan, consult with the Department of Food and Agriculture, Resources Agency, and the Department of Health Services.

The research program plan shall be submitted to the Joint Legislative Budget Committee and the appropriate policy committees of the Legislature by March 1, 1980.

2) UC shall report to the legislative budget committees and the appropriate policy committees by January 1 of each year on the progress of the statewide integrated pest management program, including a list of research grants funded by the program in the previous year. The report shall also describe how research priorities in integrated pest management identified by the Director of Food and Agriculture are addressed by the statewide integrated pest management program and the reason for any differences in priorities between the director and the University. Finally, before purchasing any computer equipment, the University shall thoroughly evaluate its computer equipment needs. In particular, attention should be given to: (1) leasing rather than purchasing equipment, (2) utilizing a commercial time-share service, and (3) coordinating with the Department of Food and Agriculture's pesticide information systems. The January 1, 1980 report shall provide the details of the computer equipment augmentation program.

The director responded to both parts of the Budget Conference Committee's request in a report submitted in December 1980 (appendix VI).

During the 1981-82 fiscal year, several changes in administration occurred. Ivan Thomason resigned as director and returned to full-time teaching and research in the Nematology Department at UC Riverside. Jim Lyons was asked to return as the IPM Project director. Lyons had resigned as associate dean at UC Davis and now served half time as assistant director of the Agricultural Experiment Station in the office of the vice president—agricultural sciences; he would serve as director of IPM as part of those duties. Concomitant with these changes, Andy Gutierrez resigned to return full time to the Division of Biological Control, UC Berkeley, and Howard Ferris, Department of Nematology, UC Riverside, was appointed associate director. Mary Louise Flint became assistant to the director and chair of the Technical Committee.

In the earliest years, administrative support was furnished by the dean's office in the UC Davis College of Agricultural and Environmental Sciences. However, in 1982 Leah Hansen was employed by the IPM Project as an administrative assistant and Suzanne Roodzant as a senior clerk, and IPM took over its financial and personnel administration. By 1982-83, staffing reached 22 and remained stable at about that number. See appendix XII for a complete list of staff, by year. The 1981 organizational chart (figure 1) describes the structure of the Project at the beginning of this period, and the 1984 chart (figure 2), the structure near the end.

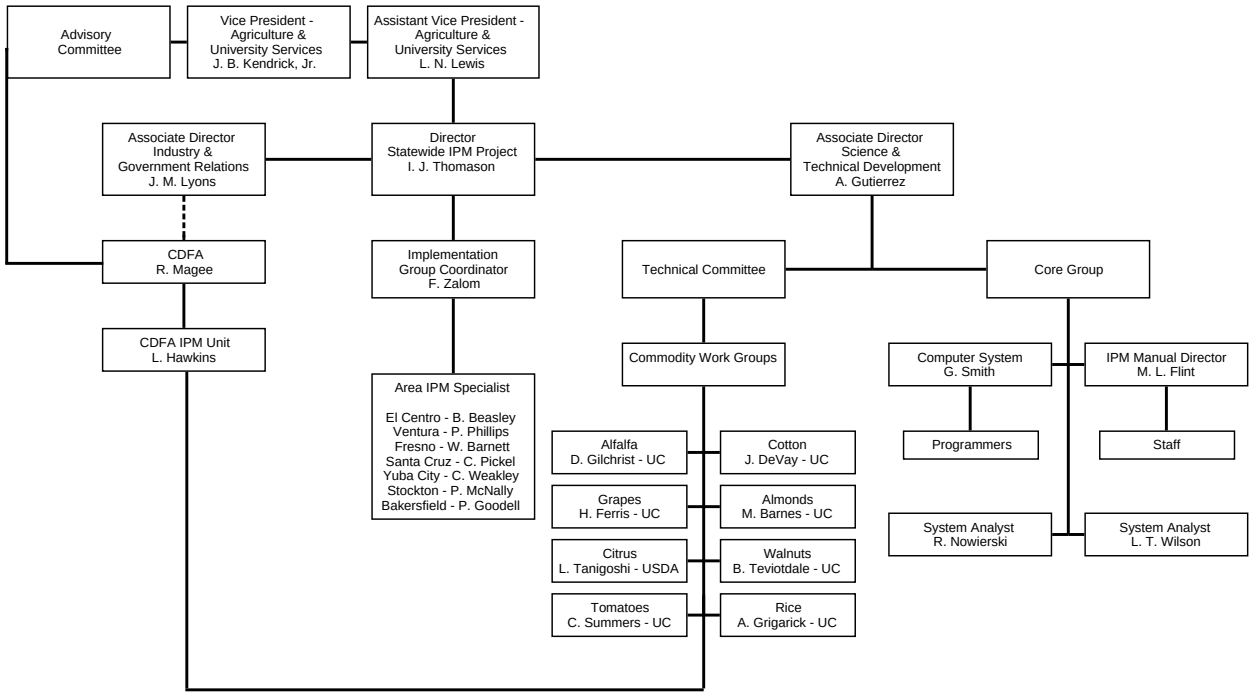


Figure 1. 1981 Statewide IPM Project Organizational Chart.

In March 1982, Vice President Kendrick established a committee to review the overall operations, communications, administrative structure, and effectiveness of the IPM Project. The committee was not charged with evaluating research or implementation programs for technical accuracy or validity. The Evaluation Committee's membership was divided into three subcommittees charged with assessing different aspects of the Project's operation. The subcommittees and their membership were as follows:

Subcommittee on Coordination and Administrative Structures

Hal Reynolds	UC Riverside, Chair
John Anderson	UC Berkeley
Bill Hambleton	CE, Fresno County
Larry Rappaport	UC Davis

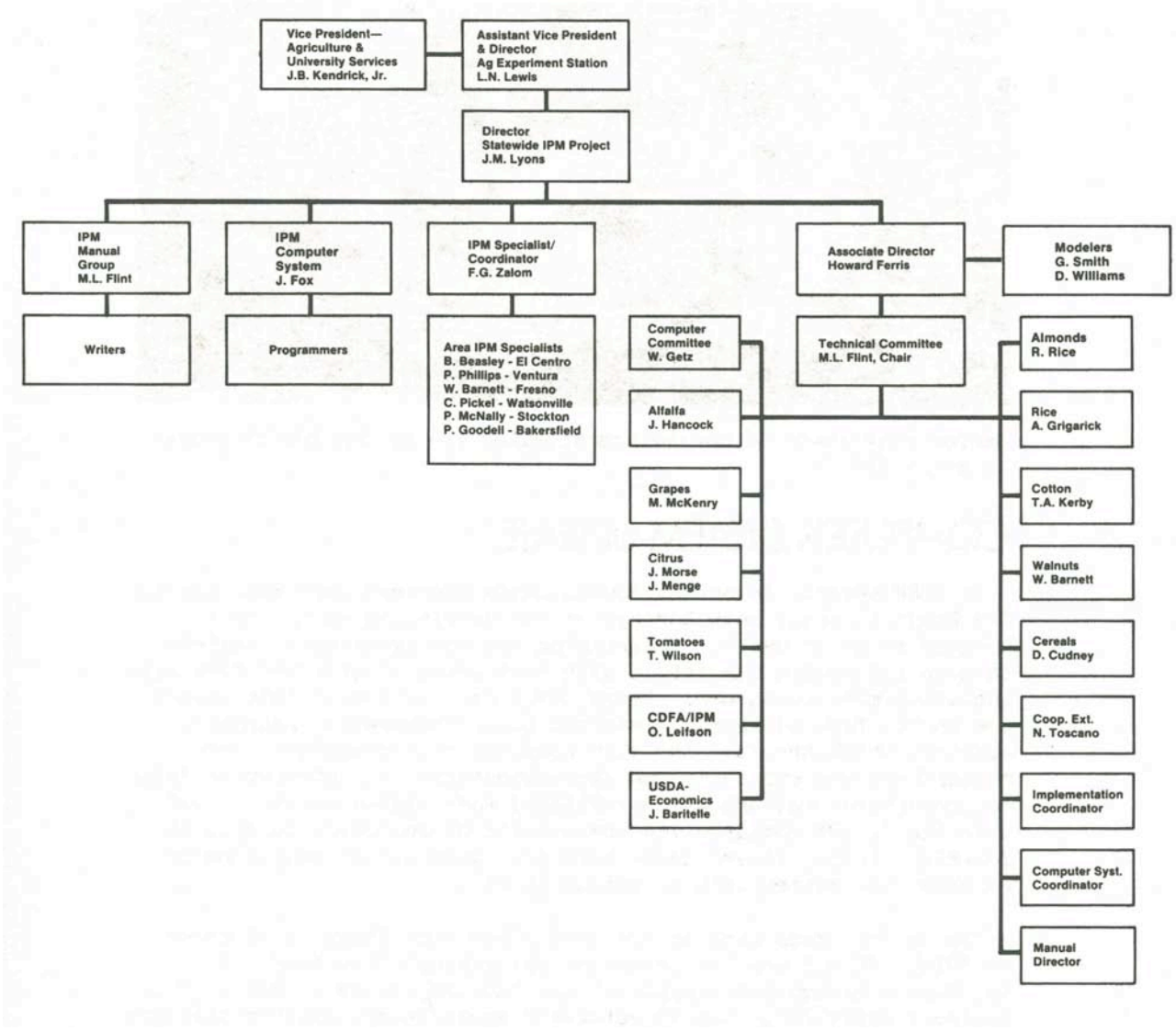


Figure 2. 1984 Statewide IPM Project Organizational Chart.

Subcommittee on Program and Budget

Don Dahlsten	UC Berkeley, Chair
Seymor VanGundy	UC Riverside
Jim DeVay	UC Davis

Subcommittee on Usefulness (Delivery Systems)

Nick Toscano	CE, UC Riverside
Warren Johnston	UC Davis
Cal Qualset	UC Davis

The full report is given in appendix VII. For each topic there was discussion of strengths and weakness. The general conclusions and recommendations were as follows:

> As a general conclusion, the Review and Evaluation Committee found the UC Statewide IPM Project has been highly successful in bringing together a large number of scientists from a broad range of discipline to focus on the complex interaction of crop and pest management. Opinion was expressed that the State of California and the University can be particularly proud that the program has achieved such success in a relatively short period of time.
>
> As with any project of this magnitude, there is a need for constant evaluation and adjustments to keep a focus on the primary objectives and to make improvements where needed. The major area of concern revolves around the issue of "communication" and the following specific recommendations should be considered:
>
> 1) Increase use of established Experiment Station and Cooperative Extension lines to inform departments and their chairs, program directors, campus-based disciplinary specialists, and county-based farm advisors of the procedures priorities and progress of the Project.
> 2) Involve the above lines of communication within the Experiment Station and Cooperative Extension to provide greater input in establishing research priorities and in developing proposals.
> 3) Involve area IPM specialists more closely within the commodity workgroups of the Project and be sure they have representation on the Technical Committee.
> 4) Encourage greater interaction between the campus-based disciplinary CE specialists and the IPM Project so that there is a better linkage among all of the disciplines involved.
> 5) Provide for greater interaction between those involved in the IPM commodity workgroups and the various marketing order/industry funded commodity groups. This would ensure more efficient use of the collective funds available for research on the various commodities.

Field Implementation

As stated previously, the primary goal of the IPM program was to have integrated pest management practices implemented in the field. A key element in delivery of information to growers was the opportunity to employ area-based CE staff. Their implementation efforts made it possible for research done in the Agricultural Experiment Station to be quickly tested and validated in the field and for information on these methods to be passed on to growers. To facilitate their activities and to introduce the concept of an area IPM specialist into the existing county-based CE structure, Frank Zalom, as the extension IPM coordinator, systematically met with county CE staff throughout the state at their office conferences and in other venues to listen to their concerns about the new program and to repeatedly explain the purpose and benefits of the program. Another event that greatly facilitated the acceptance of the program surfaced with the employment of Carolyn Pickel and Bill Barnett as the first area IPM specialists. Carolyn was an

Carolyn Pickel in a field of Brussels sprouts.

advisor in Santa Cruz County working on integrated pest management programs with apples and pears but also took on a project to manage pest problems with Brussels sprouts on the Wilder Ranch. Her success in this project was duly noted by Assemblyman Sam Farr and hence gave the IPM Program a good friend in the Legislature. Bill was an entomology advisor in Fresno County who was highly respected by his peers in the San Joaquin Valley. Bill had been a private pest control adviser before joining CE and also had the confidence of many in the private sector. He was invaluable in helping smooth the integration of the new area IPM advisors into the established CE county-based structure.

Bill Barnett (center), and students in a hands-on training class at Kearney Agricultural Center, Parlier.

However, the question of their duties and responsibilities, and the title of advisors vs. specialists (an issue that would surface again in several ways as time went on), arose with the first three area IPM advisors. As they began to be involved in their program activities, they ran into the vagaries of a peer-reviewed merit and promotion process. Who were their peers? The individuals expressed concern that they were doing work more closely related to specialists than advisors, and that their advancement should be made on that basis. After discussion with the Cooperative Extension director, the administration decided that the area IPM advisors could be reclassified as specialists, but with the understanding that they would be specialists with a small "s" to distinguish them from the disciplinary UC CE "big S" Specialists. At this time there was no administrative relationship between CE specialists and campus departments, so with a simple decision by the CE Director, they all became area IPM specialists. As the Project moved forward to add two additional positions, they were recruited and appointed as area IPM ("little s") specialists. Dr. Phil McNally and Dr. Pete Goodell were recruited and hired as area IPM specialists in April and May 1981, respectively.

Phil Phillips, left, with UC IPM since 1980, talks with a strawberry grower.

By the end of the 1980-81 fiscal year, seven area IPM specialists were in place throughout the state. Their assigned areas of responsibility and headquarters location were

William W. Barnett	Central San Joaquin Valley (Fresno)
Charles A. "Bud" Beasley	Desert Areas (El Centro)
Peter Goodell	Southern San Joaquin (Bakersfield)
Phillip S. McNalley	Northern San Joaquin Valley (Stockton)
Phillip A. Phillips	South Coast Counties (Ventura)
Carolyn Pickel	Central Coast Counties (Watsonville)
Craig V. Weakley	Northern Sacramento Valley (Yuba City)

Early IPM implementation staff meeting. Clockwise from left: Ivan Thomason, Craig Weakley, Jim Lyons, Bud Beasley, Phil Phillips, Pete Goodell, Frank Zalom, Bill Barnett, and Phil McNally.

An area IPM specialist had the day-to-day responsibility of getting practical information about integrated pest management out to users. The existence of a staff of area IPM specialists was one important way the IPM Project differed from many other research programs in universities across the country. Having such county-based CE specialists associated with the Project allowed an IPM program to be followed from its early research stages to its use in the field by commercial growers and pest control advisers; many other programs were stymied by their inability to put the results of their research to practical use. Campus-based researchers also benefited from having frequent interaction with those who would later implement the program. In addition, the area IPM specialists kept close contact with the IPM manuals group as it prepared extension publications that would help them deliver programs.

Area IPM specialists acted as a special resource on IPM for farm advisors. Farm advisors called on them to assist in workshops or advised them on how to meet the pest management needs of growers and PCAs in their county. Area IPM specialists kept farm advisors up to date on the latest IPM developments and often cooperated with them in research and demonstration projects involving such techniques as monitoring, sampling, and evaluating treatment thresholds and alternative pest management strategies. At the request of farm advisors, an area IPM specialist could work with growers or PCAs directly on the farm, or in workshops or other educational forums. The relationship between an area IPM specialist and a farm advisor was a long-term, day-by-day one as compared to statewide CE specialists who helped solve specific new or special problems and provided training within a single discipline.

The area IPM specialists reported through their statewide coordinator to the pest management program director, UC CE. The UC IPM Project director and the UC IPM Technical Committee advised them on their activities. County directors within the area IPM specialist's designated region also advised on promotions and local activities. Each of the area IPM specialists had earned an MS or PhD degree in some field of plant protection and had several years of practical field experience before joining the IPM Project.

The key functions of the area IPM specialists were

- Coordinating and demonstrating IPM programs over a multi-county area;
- Participating in field research coordinated by Agricultural Experiment Station researchers and CE specialists;
- Adapting IPM research for commercial agriculture;
- Conducting applied research to meet local pest management needs;

- Providing a practical perspective on UC IPM Project research priorities;
- Keeping farm advisors up to date about the latest IPM information;
- Cooperating with farm advisors to promote IPM programs in the private sector.

The area IPM specialists played the pivotal role in bringing the results of most major IPM research programs to the field, and their jobs required that they move their emphasis from crop to crop every few years so that in time they would have been involved in most major crops in their region. Once a program was well adapted for commercial use in their area, county farm advisors were expected to gradually take over the job of seeing that local growers and PCAs learned about it. Because of the periodic movement from one crop to another and the fluidity of their positions, one area IPM specialist suggested that they would be better termed "IPM facilitators" rather than specialists. Their expertise was to be in developing, rather than maintaining, programs.

In the 1980s, computers began to play a greater role in agriculture, especially in pest management. The first priority for use of the IMPACT computer system, as the Project's computer network became known, was county implementation, and all of the area IPM specialists took part in demonstrating the Project's computer system to county staff and other interested people. Pete Goodell surveyed the use of microcomputers in agriculture in the southern San Joaquin Valley counties and organized a local "computers in agriculture" group to assess software and hardware needs for agricultural uses.

Frank Zalom suggested that it would be more effective if a second coordinator could be developed within the Project to share responsibilities, and in 1984 Bill Barnett was appointed as area IPM advisor/coordinator for tree fruit and nut crops. Frank remained as IPM specialist/coordinator with responsibilities for field and row crops.

In 1985 the issue of the title "area IPM advisor" vs. "area IPM ("little s") specialists" once again arose. After several years as IPM specialists, two concerns became apparent: one was their job description, and the other was the impact of their job description on criteria used in their merit and promotion reviews.

It became clear that standard farm advisors with commodity responsibilities recognized the need to develop long-term management strategies to ensure the health of a given crop industry in their county. The area IPM advisor performed basically the same function, incorporating appropriate monitoring, sampling, threshold evaluation, and alternative management strategies to improve existing agronomic or horticultural systems. To vigorously implement IPM strategies and technologies developed in the research system, the Project needed the area IPM staff to follow the model of an advisor, not the model of a standard specialist. And this distinction began to surface in some of the merit and promotion packages. Several of the area staff asked to be reclassified to advisors because of their perception that they were being disadvantaged in the system when classified as specialists. As in the first year of the IPM Project, this was a fairly simple administrative issue, and the decision was made to reclassify all the area staff as area IPM advisors.

Concomitant with this change, all of the area IPM advisors were invited to attend the IPM Technical Committee meetings and to evaluate proposed research with special emphasis to applicability for

their areas. This established a more direct line of communication within the program to enhance the linkage between research, education, and field implementation.

Sue Blodgett, left, leads grower meeting in a Sonoma County vineyard.

In 1985, Craig Weakley left his IPM position to become the pomology farm advisor in Sutter County. As a result, the Project began a search for an area IPM advisor for the Sacramento valley region.

In 1989 Dr. Sue Blodgett joined the Project as an area IPM advisor located in the Sonoma county CE office with responsibility for serving the north coast region. Her position was out of the normal pattern for area advisors since the county provided her salary and the IPM Project provided her support. This brought the total cadre of area advisors to eight.

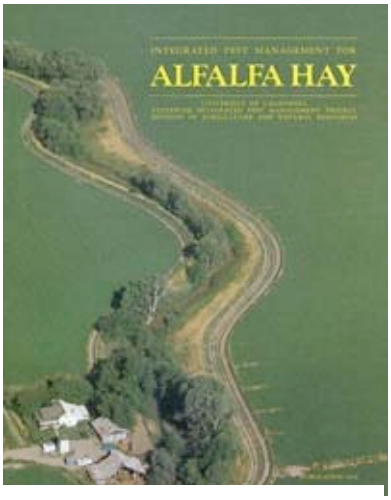
IPM Manuals

The IPM manual group, established in January 1980, was a key part of the implementation effort from the beginning. The manuals and the photographs prepared along with them provided a useful communication tool for the area IPM specialists and farm advisors. The manuals rapidly became a very attractive and visible marketing tool not only for promoting integrated pest management to growers and PCAs in California, but to gain more recognition for the IPM Project itself. An IPM manual steering committee, with representatives from CDFA and UC CE, provided guidance on general manual production issues, but the real key to their success was the active cooperation of the UC AES and CE experts in the IPM commodity workgroups and the IPM advisors. Drafts of the manuals, written by the staff in consultation with IPM commodity workgroup members, were revised based on review by researchers and comments from grower and pest control adviser representatives. The manuals, each about 100 pages during the early years, were designed as a series and followed a similar format, which was enhanced with publication of each new manual: a general discussion of crop biology and production practices in relation to pest damage; seasonal monitoring charts and guidelines; and a key to pest- and stress-induced damage. What really set these books off from any previous pest control guides was the emphasis on the ecosystem and crop ecology, biological control, practical monitoring guidelines, and the systems approach to managing pests. Over the years, the illustrations became increasingly spectacular: color photos of life stages, damage symptoms, and natural enemies accompanied the discussion of each major pest, and many line drawings, charts, and forms enhanced the discussion.

One early stumbling block in the evolution of the manuals was the decision by the UC ANR Publications group in Oakland that they did not have the staff to help with the production of the IPM manuals. As a result, not only did the fledgling IPM manual group have to write the text and supervise photography for the books, they had to obtain and supervise an outside source of graphic design and publication production. Director Flint found a freelance contractor, Naomi Schiff of Seventeenth Street Studios, to assist in these tasks, as well as freelance editors. The new publication ideas brought on by this collaboration resulted in more attractively designed books that could be produced with color photographs at a less expensive price and more rapidly than previous ANR

publications. Several years later ANR Publications adopted many of the production ideas initiated in the IPM manuals. In the end, the IPM manuals were marketed through ANR Publications and have proved to be an important source of their income over the last 20 years.

By the end of 1980-81, the manual group was well organized and productive. A manual on alfalfa had been published, one on walnuts was in press, and one on tomatoes was in the final production stages. A rice manual had been drafted; manuals for citrus and cotton were in the advanced planning stages, and color photographs of key pests and plant growth stages were being taken. In addition, Mary Louise Flint produced the Project's first comprehensive annual report describing activities and accomplishments of the Project. These reports were widely distributed throughout the Division, Legislature, commodity groups, and various agencies and organizations with interest in IPM on an annual basis and provide a history of the program.



The first edition of *IPM for Alfalfa Hay*, the first manual from UC IPM, was published in 1981.

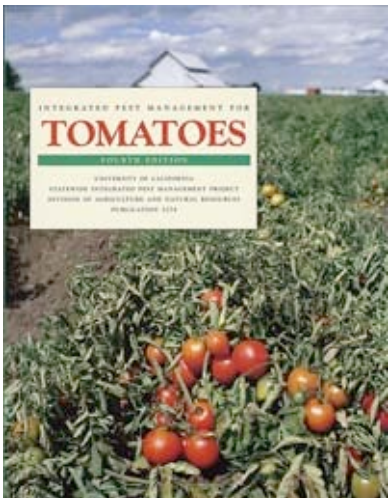
A related project undertaken by the IPM manual group during the early 1980s was a contract with the CDFA to assist in its regulatory functions by compiling directories of pesticides and pesticide alternatives for tomatoes, alfalfa, and grapes. CDFA established a committee to advise on development of these directories, and Tobi Jones, the directory coordinator, worked closely with other IPM manuals staff, IPM advisors, and other UC CE staff to create the needed documents.

By the end of 1980-81 staff of the IPM manual group located at UC Davis were

Mary Louise Flint	Director
Jack K. Clark	Photographer
Brunhilde Kobbe	Senior Writer
Paul Rude	Senior Writer
Tobi Jones	Coordinator for CDFA Directories

By 1982 three books were completed: IPM for Alfalfa Hay, IPM for Walnuts, and IPM for Tomatoes. These manuals received national attention, and several other states asked to participate in the production of future books. For instance, the Western Regional W-161 group for cotton and the states of Arizona and New Mexico helped to finance and contributed expertise to the cotton IPM manual. The potato IPM manual, initiated in 1984 as a western regional IPM manual, was supported by the Western Regional W-161 group, and the land-grant universities of Idaho, Washington, Colorado, Oregon, and Montana. Industry groups also enthusiastically embraced the IPM manuals and provided support. The California Almond Board provided partial funding for the almond IPM book. During 1982, Barbara Petersen (later Ohlendorf) was hired as a senior writer to work on the almond book, and Betty Rudd was employed as a secretary for the group. Dr. Larry Strand joined the IPM manual staff as a senior writer in 1984 to produce the potato manual.

Nine IPM manuals were produced by the Project from 1981 through 1986. These were manuals for alfalfa hay, walnuts, tomatoes, rice, citrus, cotton, almonds, cole crops and lettuce, and potatoes. The tomato book sold out after 3 years and was revised in 1985. More than 20,000 copies of the books were sold by 1987, indicating that the Project had reached many growers and pest control advisers through this medium. A 1987 survey of California pest control advisers showed that 86.4% of PCAs owned at least one IPM manual, with an average ownership of 3.8 manuals. Clearly, the IPM manuals were having an impact on California's pest management industry.



New editions of *IPM for Tomatoes*, originally published in 1982, were released in 1989, 1990, and 1998.

A new thrust for the Project was development of manuals for pest control professionals studying for their professional licenses. An agreement with CDFA provided funding to revise and produce new study guides for licensed and certified pesticide applicators. In 1978, Mike Stimmann, working under Ed Swift as the Pesticide Safety Training Coordinator, hired Jack Litewka to work with him, and the two of them collaborated and wrote the first Pesticide Application and Training Manual and study packets for pesticide applicators. Now, some years later, the material was becoming out of date and in 1986 CDFA executed a memorandum of understanding with the IPM manuals group to revise and produce new study guides. IPM manuals director Mary Louise Flint had a great interest in producing study guides for applicators as well as PCAs. She hired Patrick Marer (later O'Connor-Marer) as a senior writer on this project, and he worked closely with Mike Stimmann, then the UC Pesticide Coordinator, and Mary Louise to develop the new training materials. With a PhD in entomology and a PCA license, and as a farmer growing prunes, walnuts, and other tree fruits, Patrick had unique qualifications for this assignment.

Computer Systems

After evaluating the needs of the IPM computer network and analyzing the eleven bids submitted, the Project selected a Prime Computer, Inc. configuration for its system because of the following capabilities:

- Inter-machine management in a statewide computer network;
- Database management, including a capacity to support data storage needs for agricultural field information, pesticide registration material, meteorology, and research;
- Computational capabilities to further IPM research projects and support the scientific aspects of the user-oriented IPM program.

After the selection was announced, the IPM Technical Committee, computer staff, and administrators began setting procedures and goals for the IPM network. The Technical Committee set overall policy for use of the network. Research and implementation programs would be submitted to a subcommittee of the Technical Committee for review before they were put on the computer. Other specialized committees would discuss relevant procedures. For example, a research database committee reviewed and selected among existing programs for data storage and

manipulation, statistics, and graphics. The IPM Weather Workgroup prepared specifications for a uniform system for weather monitoring and data collection.

Programmers at Davis, Parlier, and Riverside were hired in the fall of 1980. The network-support programming, which tied the network together, stored data, and communicated with the county terminals, was a major effort for the staff at that time because the Prime system was relatively new and there was little experience with it.

Before space was renovated and computer system installed, programmer Gabor Sepfy and senior programmer Buz Dreyer worked via modem.

In the first year of the Project, Jerry Hatfield, LAWR, UC Davis, had been awarded a cross-commodity research grant from the Project, "Development of Weather Systems for California and Dissemination of Weather Data for IPM." This project was the basis for obtaining and organizing the weather information needed to support IPM programs. He used these funds to hire and support a biometeorologist for this activity. Joyce Fox (later Strand) was employed on this grant, and, after the first year, she was relocated from LAWR to the Wickson Hall IPM facility to give her access to the computer so she could review programs and design. When pondering a third-year proposal for this grant, Hatfield suggested that the Project should employ Joyce directly rather than through the grant system; in 1981 Joyce joined the IPM computer systems staff.

The system became fully operational in 1981-82. The network—identified as the "IMPACT" (Integrated Management of Production in Agriculture using Computer Technology) system—consisted of one large central computer in Davis; three smaller district processor computers at Davis, Riverside, and the Kearney Horticultural Field Station at Parlier; 12 terminals in county extension offices; and several research terminals at the Berkeley, Davis, and Riverside campuses (figure 3).

Computer terminals in the counties gave extension personnel (including area IPM specialists) access to weather data, degree-day calculations, communications (news and mail facilities), models, data sharing, and some statistics and graphics packages. University research personnel also had access to these programs and could use programming languages to develop their own research programs, as could county personnel who requested use of program development capabilities.

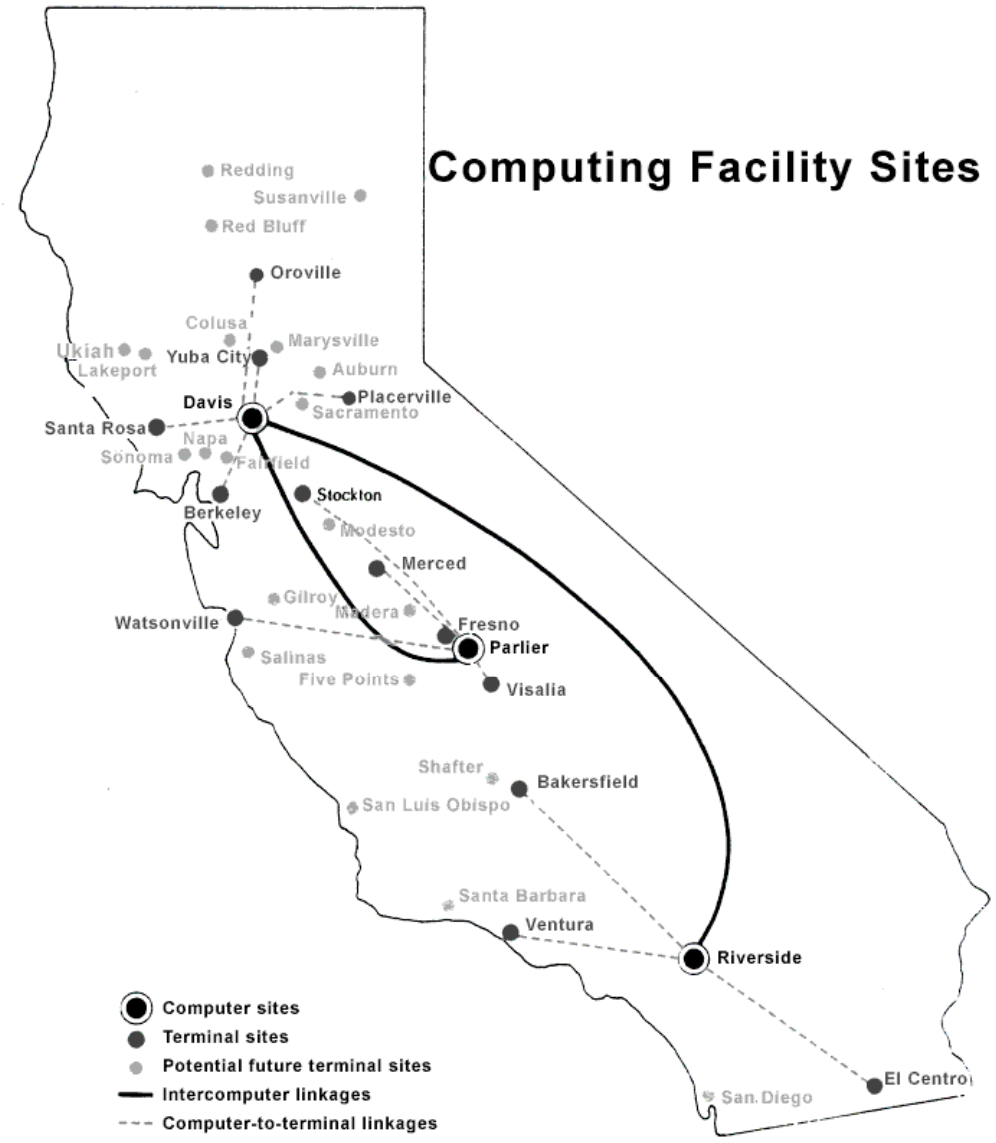


Figure 3. Statewide IPM Project IMPACT Computer Network.

Computer network staff members in 1982 were

Gary Smith, Coordinator
William (Buz) Dreyer, Senior Programmer
Edward G. Morgan, Senior Programmer
Joyce Fox, Biometeorologist
John Rasmussen, Programmer, Parlier, Kearney Res. & Ext. Center
Ann Strawn, Programmer, Entomology, UC Riverside

In addition to hiring computer staff and remodeling laboratory space for the new computer facility, the Project hired two researchers to provide expertise in systems analysis to commodity workgroups. Dr. Robert M. Nowierski, UC Berkeley, was assigned to work with the alfalfa

commodity group on sampling procedures for alfalfa insect pests and to work on the role of weeds in alfalfa stand decline. Dr. Ted Wilson, located at the Kearney Horticultural Field Station at Parlier, worked with the cotton group to improve IPM in that crop, including further elaboration of crop interactive models, sampling programs for spider mites and other cotton pests, and quantification of relationships between irrigation practices and pest problems.

Until 1983, six types of programs were available on the IMPACT computer system: general crop information, models or pest projections, weather data storage, degree-day calculations, news and mail programs, and research-mode programs. In 1983 a summary of the pest management recommendations published by the UC Division of Agricultural Sciences was added. This database included more than 6,000 individual recommendations that prior to this time, were published only in hard copy. While most of these were for using pesticides, some included biological or cultural control methods. Recommendations were cross indexed according to crop, pest species, pesticide or other control method, and the publication from which the recommendation was pulled. The elements of the program and its design were developed with Gary Smith, Buz Dreyer, and Joyce Fox, in consultation with Mike Stimmann and Melanie Zavala. Mike Stimmann, Statewide Pesticide Coordinator, CE UC Davis had the responsibility for maintaining the technical content of the database.

Area IPM advisor and staff member use IPM computer system from standard IPM terminal and printer installed in Fresno County CE office.

Hardware changes to the IMPACT computer system in 1984 made it more accessible to a broader range of users. New dial-up capability allowed county farm advisor offices that were equipped with CompuPro microcomputers, and researchers with their own microcomputers, to access the system using a telephone line and modem. Also about that time, the weather database expanded to include all weather data from the California Irrigation Management Information System (CIMIS). CIMIS, developed by faculty in LAWR at UC Davis for the California Department of Water Resources, was designed so that the data could be readily integrated with the IPM Project weather database, and came online with 43 automated agricultural weather stations located throughout the state.

The Project took a major step the next year by opening up the IMPACT computer system access to users from the University, government agencies and schools, and private sector businesses and individuals. With this advance, IPM's special resources, such as the extensive weather database and the pest management recommendations database, were available to all who could benefit from their use, though in fact relatively few had the necessary equipment. The computer group began developing software for microcomputers about this time also. The first programs written were the UC pest management recommendations database and a set of phenologies of insect pests of stone fruits.

Research Grants Program

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

1980-81	Andrew Gutierrez	Biological Control, UC Berkeley
1981-86	Mary Louise Flint	IPM Manuals Group, UC Davis

During the first six years of the IPM Project, the research grants program was focused around individual crops and creating multidisciplinary teams in each crop that would foster a systems approach to pest management. An IPM commodity workgroup was established for each funded crop. The IPM commodity groups were the most important planning and decision unit for research funded by the Project during this period. The groups reviewed the status of research and pest management in the crop, identified data gaps, solicited research proposals, evaluated submitted proposals, and made recommendations to the Technical Committee on priorities for Project funding. Although studies of multi-crop significance (cross-commodity proposals) were funded, 95% of the research funds were directed through the commodity group system to the nine selected commodities: alfalfa hay, grapes, cotton, citrus, almonds, walnuts, tomatoes, cereals (wheat and barley), and rice.

This commodity-oriented approach to soliciting and funding research reflected the UC IPM Project's emphasis on protecting overall plant health and crop production. IPM commodity workgroups included a multidisciplinary array of research and extension personnel who worked in the crop but viewed it from such varied perspectives as agronomy, horticulture, plant pathology, entomology, nematology, weed science, soil and water science, mathematics, or economics. Research projects were often designed to be complementary, so the sum of a commodity group's funding requests over a few years could be viewed as a total package for an evolving IPM program in that crop. It was the responsibility of each commodity group to see that research led to methods suitable for grower use within a reasonable amount of time and provided a plan for making these methods available to growers and PCAs. In devising an implementation plan, commodity groups and researchers worked closely with area IPM advisors and other UC CE staff. They also participated in developing the IPM manuals.

Crop Models

Early in the grants programs, a research priority area identified by most IPM commodity workgroups was the development of a crop model that could be used to link research results from several projects and identify where future research efforts needed to be directed. A stated goal was to develop a crop model for all commodities except cotton; the cotton IPM commodity group planned to work with existing cotton models developed in other states. Many of the models were primarily phenological models for determining timing of developmental events, although a few included carbon pathway and yield components. Researchers designed all plant models to be linked with pest models. The 1983 UC IPM Annual Report provided an analysis of modeling biological systems and that is presented here in part, as it formed the framework for much of the research that followed.

Modeling Biological Systems. The commodity groups funded by the UC IPM Project placed considerable emphasis on the development of models of crop production systems and their associated pests. Models, in any sense of the word, are simplifications of larger, more complex systems, structures, or events. They promote understanding of the form and function of the system they represent. However, their accuracy is limited by their simplicity and by the modeler's understanding of the system.

In 1983 it was estimated that there were some four million biology-related publications in print. These publications contained information about the structure and functioning of biological systems at resolutions ranging from the molecular, through the population and community, to the global level. In crop and pest management, the interest is in biology at the population and community level. The crop is a population of plants, and its community includes the populations of pests and beneficial organisms that interact with the crop and with each other in the field. However, understanding the biology at this level depends on understanding biology at much finer levels of resolution. In other words, crop yield represents the summation of the molecular activities that occurred during the growing season to produce that yield.

Many variables must be considered to describe the interacting populations that form the community centered on a particular crop or sequence of crops. The human brain is capable of tracking the performance of a maximum of seven variables, provided they are independent and not interacting with each other. The biology of a crop production system is far more complex; as the number of interactions increases, there is a corresponding decrease in the number of variables that can be effectively analyzed. Fortunately, electronic technology can be employed to store and track the behavior of many variables. Basic to the use of such technology is the formulation of a model, stating the modeler's hypothesis about how the system functions at a specified level of resolution (in this case, the population or community level). The hypothesis is usually developed with equations that describe the processes and interactions within the system. A common constraint of models is that they require specification of the limits or boundary of the system being modeled. Such boundary decisions made to aid modelers may minimize important factors such as environmental perturbations, the geographic distribution of neighboring crops, and pest immigration. Nonetheless, hypotheses about the system, when formally stated as models, are then testable at the field level and can be reevaluated and refined based on field observations.

Types of Models. Several types of models are useful for crop and pest management purposes. Phenology models predict the timing of developmental events. They are frequently based on temperature or on units of heat summation called degree-days. The predicted events might include bud break, flowering, vegetative growth, fruit growth, or the appearance of various life stages of pest populations. Some phenological models take into account factors other than temperature, including humidity, chilling requirements, and other environmental conditions. Models at this level are useful for timing crop protection activities or for timing monitoring and assessment efforts for the detection of pest species.

More complex than phenological models are population models, which predict not only the timing of the events, but also their magnitude. For example, a pest population model would predict not only the occurrence, but also the magnitude, of the pest outbreak. When sufficient data are available on the impact of the pest on crop growth, the population model could be used to estimate the

expected crop damage. Such models provide a basis for economic threshold considerations, and ultimately for optimization of returns from the system, either in the short term or over a multiyear cropping sequence.

Other models fall under the category of management decision models. They include predictors of the relationship between the intensity of the monitoring or sampling effort and the associated precision of the pest population estimate. These models allow assessment of the risk involved in acceptance or rejection of a management decision. Management decision models may also project the efficacy of a management strategy given the current size of the pest population, the current development of the crop, and the current environmental conditions. Once again, the accuracy of the predictions and projections from such models is limited by understanding the complexities of the system and by necessary definition of a restricted boundary to the system. The models are extremely useful, however, in promoting an understanding of the structure of the systems, thereby revealing gaps in knowledge and appropriately and effectively directing research activities.

Part of the complexity of crop community management is the understanding of how individual pest populations interact with the crop and with each other. Such understanding can allow prediction of repercussions throughout the system resulting from perturbation of one population or of one part of the system. The interaction among the individual populations is primarily integrated by the plant, and the effect of this integration from a practical standpoint is reflected in yield and quality of the crop. Central to the UC IPM Project modeling activities was the development of plant models. These models described the important plant growth processes involved in crop production. They vary in their complexity, but all simulate the production of photosynthates under given conditions of temperature and sunlight, and the partitioning of that energy into respiration or production of leaves, stems, roots, and fruit over time. More complex models may account for varying supplies of water and nitrogen, impact of pruning, soil type, or other factors.

The Model Building Process. Each commodity group and researcher had a somewhat different approach to model building, but basic strategies were similar. The first step was determining the objectives of the model, the type of model, and level of complexity necessary to describe the system adequately. Relevant variables were then chosen and the model conceptualized. The boundaries of the system had to be clearly designated so intrinsic and extrinsic factors could be separated. The next step was to place the model in a mathematical framework. The parameters of the mathematical model were estimated through experimentation, analysis of data sets from collaborators, or review of available literature, or from the opinions of experienced specialists. Completing this step took several years if new experiments were necessary to collect the appropriate data. Once the parameters were estimated, the model could be translated into computer language and installed on a computer system. Lastly, researchers validated the model by comparing its simulations to field biology observations. Sometimes this process revealed the importance of a factor heretofore not considered of consequence for determining timing of events, yields, or population increase; such factors included chilling requirements, day length, or natural enemies. The validation process took several seasons if adequate historical data were not available.

Although an initial model structure may have been completed (as shown below in figure 4, a diagram of the Denison/Loomis Alfalfa Model), the model building process was never really finished. As research provided more detailed information about how a crop grows or how pests

damage the plant, the model could be developed into a more accurate predictor of events in the field. A model could only reflect the current state of knowledge about the factors affecting plant growth, and there is always room for improvement. However, modeling activities could effectively and efficiently direct research programs toward the prescribed goal of describing a crop or pest community. In the process, they provided a forum for integrating information, identifying critical data gaps, and for promoting interdisciplinary research.

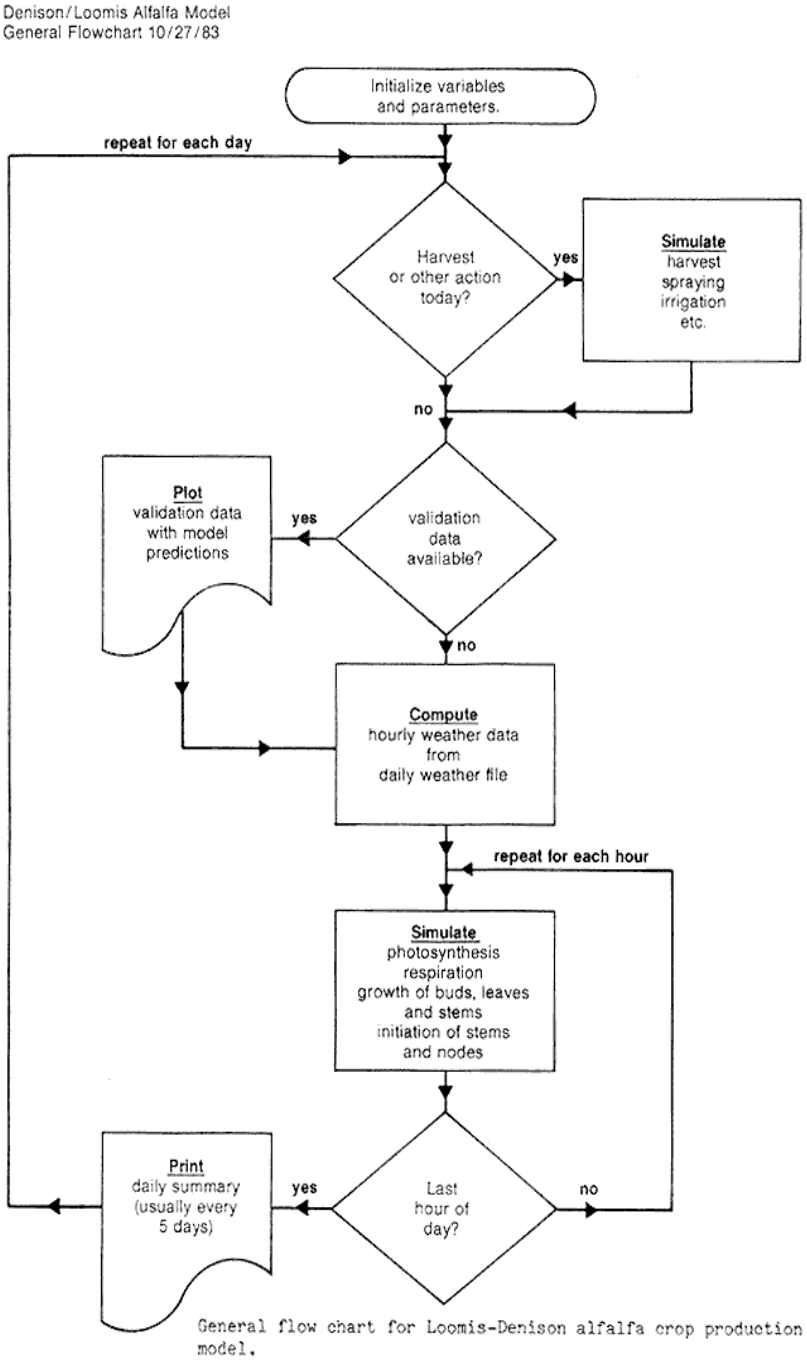


Figure 4. Denison/Loomis Alfalfa Model General Flowchart.

Accomplishments of the Commodity Groups 1980-86

The commodity groups were instrumental in the Project's early success. Their interdisciplinary review of objectives and research proposals was innovative and encouraged an exciting new approach to pest management research. In many cases these groups brought together into cooperative projects workers from diverse disciplines that might not otherwise have interacted. Commodity groups also fostered better communication between research and extension workers in many commodities. The chairs of the IPM commodity groups served on the Technical Committee, and Technical Committee meetings provided a forum for discussion of common problems, suitable research approaches, and priorities among the commodities.

By 1986, many of the original research goals established by the commodity groups had been met. Between the beginning of the IPM grants program in 1980 and 1986, more than $4 million in research funds were awarded to 135 individual proposals with a duration that varied from one to five years, although most were completed in about three years. Data gaps and pest management research needs for all of the selected crops were identified. Existing information was translated into usable management guidelines in the form of integrated pest management manuals (with the exception of cereals, for which compilation of a manual had just begun). Major studies on crop growth as related to environmental factors and some biotic factors had been completed for all the commodities, and preliminary phenological or physiological models of crop growth were tested. Substantial information on the impact of many diseases and most major arthropod pests on crop growth had been collected. Sampling methods and decision guidelines had been developed for many important pests and demonstrated in the field. However, despite the completion of the original goals, each of the IPM commodity groups could identify new research needs for integrated pest management and were reluctant to pull out of the IPM Project to be replaced by new commodities, as had been anticipated in the original project plan. At the same time, many new commodities were interested in participating in the Project; however, the IPM Project organizational structure was not amenable to an infinite number of workgroups. A new structure was needed.