Important Issues in Ecologically Sound Integrated Pest Management

A Student Debate

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Most graduate programs require students to participate in a course or seminar that allows them to develop skills in scientific presentation. Few programs, however, prepare students to locate, read, analyze, and critique the types and sources of information that so frequently underpin the public debates that precede most policy decisions. Still fewer programs allow students to practice using incomplete or contradictory information to formulate and defend arguments on policy, ethics, or related issues. Increasingly, entomologists find themselves involved in a public arena, using such information to discuss matters that have broad consequences for science and society. Scientists who enter the workplace with debating skills will be more prepared to shape effective policy, prioritize research agendas, defend their discipline against budgetary cutbacks, and/or confront allegations of ethical or other misconduct. This being the case, providing opportunities in graduate education for students to debate timely and important issues will benefit not only the students but also their discipline and society as a whole (Carroll et al. 1993).

This was the rationale that prompted Fred Gould and George Kennedy to organize a graduate student debate at the ESA Annual Meeting in 1993. The debates are now an annual event organized by the ESA Committee on Student Affairs. The issues addressed in these debates have ranged from the risks of transgenic crops to conservation of insect biodiversity to international aspects of entomology. Summary statements from the 1994 debate on environmental issues in biological control were published previously in this forum (Gould et al. 1996).

The format for the debates and the methods used to prepare for them have varied over the years, based on participants' experience and feedback. Currently, four specific statements related to one broad topic form the basis of the debate. For each statement, one student presents a brief historical background on the issue (15 minutes), one team argues that the statement is true (pro position), and one team argues that the statement is false (con position). Each pro and con team has the opportunity to present its argument (10 minutes) and to follow up with a rebuttal statement (3 minutes).

The participation of university departments in the debate is solicited through personal contacts, announcements in the ESA Newsletter, and by sending invitations and descriptions of the debate to chairs of all entomology (and related) departments in the United States. Departments must commit to sending a team of one or more students to the ESA Annual Meeting and providing the team with a faculty advisor. Teams typically prepare for the debate during the fall semester through seminar or discussion sessions in which students study the issues and debate the pro and con positions. Early in the semester, the debate organizers randomly assign each team a background, pro, or con presentation for two of the debate issues. Teams are free to allocate the debate presentations at the Annual Meetings among one or more team members as they see fit.

Printed below are brief summaries of statements from the debates at the 1996 Annual Meeting. Authorship is presented with each background or position paper. In reading these summaries, please keep in mind that students were randomly assigned pro or con positions, so the views presented are not necessarily the personal views of the students who expressed them. Also, please recognize that a debater must present as strong a case as possible in defense of the assigned position. In doing so, a debater will avoid mentioning details that do not support that position, except to challenge their relevance or veracity. It is the responsibility of the opposing team to point out these details. The debate organizers would welcome all suggestions for future debate topics or approaches to improve the program. University departments interested in participating in these debates are encouraged to contact the ESA Student Affairs Committee.

For clarity and ease of reading, all acronyms used throughout these debate statements have been listed and defined below:

CRP Conservation Reserve Program
CSRS Cooperative States Research Service
EBPM ecologically based pest management
EPA Environmental Protection Agency
EQIP Environmental Quality Incentive Program
ESA Entomological Society of America
FACT Food, Agriculture, Conservation, and Trade Act
FAIR Federal Agricultural Improvement and Reform Act
FDA Food and Drug Administration
FIFRA Federal Insecticide, Fungicide, and Rodenticide Act
FQPA Food Quality Protection Act
IPM integrated pest management
NRCP Natural Resources Conservation Program
NRCS Natural Resources Conservation Service
SARE Sustainable Agriculture Research and Education
USDA United States Department of Agriculture
WRP Wetland Reserve Program

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Topic

The Practice of IPM Can Become More Than "Intelligent Pesticide Management"

Background

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Most definitions of integrated pest management (IPM) have certain characteristics in common–an emphasis on economic protection from pest damage and achieving a more favorable environmental outcome than would occur in the absence of IPM. Most definitions address social or societal consequences; for example, IPM is "the intelligent selection and use of pest control actions that will ensure favorable economic, ecological, and sociological consequences" (Rabb 1972). Other definitions, such as that of Way (1977), stress the dynamic, continually improving and situation-specific nature of IPM, "the balanced use of such measures, biological, cultural, and chemical, as are most appropriate to a particular situation in light of careful study of all factors involved." In support of President Clinton's goal of 75% of U.S. crop acreage under IPM by the year 2000, the National Coalition on IPM defines IPM as "a sustainable approach to managing pests combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health and environmental risks" (Schulze 1997).

Prior to World War II, agricultural pesticide use was minimal due largely to the high cost, scarcity, and ineffectiveness of early toxins. Farmers used cultural control methods to supplement natural control and crop resistance. Late in the 1930s, technological advances in synthetic chemistry led to the commercial use of compounds such as the organophosphate TEPP and the organochlorine DDT. These compounds were inexpensive and easily obtainable, and, along with herbicides and fertilizers, proved to be effective tools in the Green Revolution (Metcalf and Luckmann 1994). Initially, these pesticides seemed so effective that Clay Lyle, a former American Association of Economic Entomologists president, stated that attempts would be needed to prevent the eradication of various insect species (Horn 1988).

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Many high yielding crop varieties were developed beginning in the middle of the 20th century. As a consequence of the quest for highest yield under a pesticide umbrella, "major world food crops were greatly reduced in genetic diversity and natural defenses against insect pests" (Chang and Li 1980). The cultivation of pest-susceptible crop varieties, use of broad-spectrum chemicals that destroyed populations of beneficial species, insect pest resurgence, and pesticide resistance pushed many agricultural producers onto the "pesticide treadmill" (van den Bosch 1978). Probably in response to concern about chemical abuse and overuse, Stern et al. (1959) were led to propose the concept of Integrated Control. However, it was the publication of *Silent Spring* by Rachel Carson in 1962 that focused public attention on the problems associated with pesticides (van den Bosch 1978).

IPM programs should include different practices that complement each other in preventing economic damage. These programs should be dynamic and flexible, unique to a particular pest/crop situation, and, hopefully, remain effective over time by avoiding overreliance on any one tactic. For purposes of this debate, Intelligent Pesticide Management programs can maximize their longevity through strong reliance on scouting and economic thresholds, use of narrow-range minimal-risk pesticides, and other compatible chemical management strategies and tactics. At the present time, the implementation of IPM in a given setting as either Integrated Pest Management or Intelligent Pesticide Management depends largely on the value of the crop, the availability and use of broad-spectrum pesticides, the role and effectiveness of natural enemies, and the frequency and severity of major pest species.

By implementing a dynamic economic threshold, rotating insecticide classes, and conserving natural enemies through the use of more selective insecticides early in the season, cotton pest management could be considered to be Intelligent Pesticide Management.

Soybean is an example of a crop in which IPM fits the Integrated Pest Management model. Because it is not a high-value crop, returns would be low if pesticides were the major management tactic. Although over 700 species of phytophagous insects may be found on soybean, most plant damage is caused by just eight species (Way 1994). This crop's ability to withstand significant injury without significant yield loss results in high economic injury levels. Soybean growers take advantage of various control measures to minimize the need for pesticides. Biological control is practiced by the utilization of predators, parasitoids, and epizootic pathogens; however, it is reasonable to ask whether soybean growers actively use biological control or simply benefit from natural control. Small blocks of early maturing varieties or early planted soybeans can be used as trap crops that may be treated with minimal amounts of insecticide to reduce pest populations in later maturing main plantings. Pesticides are used, but only when monitoring shows that pest populations exceed economic thresholds.

Pesticide use is viewed differently in other cropping systems, as illustrated by several statements by a National Academy of Sciences panel (National Academy of Sciences 1969). The panel stated that "pesticides can be the very heart and core of an integrated system." It also noted that in many situations "chemicals provide the only acceptable solution" and that "they are indispensable to modern society."

IPM in some high-value crops tends to support these statements. In cotton, for example, extensive pesticide usage can be viable economically. A diverse pest complex and an inherent lack of tolerance to insect damage make the use of pesticides vital to successful cotton production (Horn 1988). By implementing a dynamic economic threshold, rotating insecticide classes, and conserving natural enemies through the use of more selective insecticides early in the season, cotton pest management could be considered to be Intelligent Pesticide Management. In Texas, IPM producers have been defined as those who use scouting, economic thresholds, and 70% of weighted management practices important to IPM in the particular region. Sixty-four percent of Texas cotton producers farming 68% of the acreage qualify as IPM producers (Fuchs et al. 1997).

Throughout history, a multifarious array of methods and practices intended to reduce pest populations has been developed. The control tactics used in a particular situation depend on various attributes of the pest/crop relationship. A number of factors, including length of crop production period, crop value, role of natural enemies, and the availability and selectivity of pesticides may influence the level of reliance on insecticides and the utility of Integrated Pest Management in modern cropping systems. Regardless of the commitment of a particular grower or group of growers to IPM principles, pursuit of President Clinton's challenge is certainly a lofty goal for the American farmer.

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Pro Position

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Not only can IPM become more than intelligent pesticide management, it already has achieved this goal in a growing number of systems. Ultimately, IPM must continue to move beyond intelligent pesticide management in all systems to meet the long-term goals of safe, economically viable, and sustainable agriculture (Cate and Hinkle 1993, Benbrook et al. 1996, National Research Council 1996). Ecologically based pest management (EBPM) attempts to use judiciously and integrate compatibly multiple tactics to suppress multiple pests (not just insects) in ways that complement and facilitate natural controls. These tactics include biological control, cultural practices, crop breeding, genetic engineering, mating disruption, and pesticides.

In EBPM, pesticides play an important, though secondary, role, but the emphasis is switched from correction of pest outbreaks to prevention of outbreaks. Intelligent pesticide management retains pesticides as the primary and, in many cases, the only management tool. Although the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) includes a broad range of control tactics under its definition of pesticide, in current practice Intelligent Pesticide Management deals primarily with chemical pesticides. Management of these pesticides typically consists of monitoring pest populations and using economic thresholds to determine when to apply pesticides that are as target-specific as feasible. The management of chemical pesticide usage is an important first step along the continuum from conventional, pesticide-dependent, management programs to more ecologically based preventative approaches. However, EBPM is the most "intelligent" way to manage many problems associated with use of pesticides (e.g., resistance development, declining availability and increasing costs of pesticides in certain crops, secondary pest outbreaks, negative environmental and public health impacts).

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Several examples demonstrate how EBPM is moving from a concept toward commercial adoption. Academic programs, such as the Sustainable Agriculture Research and Education Program (http://www.sarep.ucdavis.edu) and the Sustainable Agriculture Farming Systems Project (http://agronomy.ucdavis.edu/safs/home.htm), support the generation and distribution of practical information on EBPM. Cooperative efforts among farmers, researchers, cooperative extension personnel, and pest control specialists facilitate the development of pest management programs that are less reliant on chemical pesticides. An example of this is the Biological Integrated Orchard Systems program (http://www.caff.org) that started in California almond orchards and subsequently has been extended to other crops. Commercial adoption of EBPM is occurring in a number of crops, including grape production in California vineyards (Benbrook et al. 1996). Programs also are being initiated that educate consumers about IPM and enable them to select products that are produced using EBPM; one such approach is certification programs that provide IPM labels for products (Benbrook et al. 1996). These and other efforts are encouraging development and adoption of EBPM. However, advancement in adoption of EBPM has been uneven because the knowledge base, pest management tools, market incentives, policies, and the time required to make the transition vary from region to region, grower to grower, crop to crop, and pest to pest. Adoption of EBPM has been most successful when chemical pesticides have not been a viable control tactic or consumer pressure to develop alternatives has been strong.

The transition from intelligent pesticide management to a more sustainable, ecologically based management system likely will accelerate in the future. Problems that currently impede the more widespread adoption of EBPM are not insurmountable obstacles and likely will become less obstructive over time (Benbrook et al. 1996, National Research Council 1996). For example, the rising costs of developing, purchasing, applying, and regulating pesticides increasingly may make them less viable economically compared to EBPM. In addition, successful implementation of EBPM will be enhanced by: (1) technological advances that facilitate management decisions, (2) control tactics that are more selective and less disruptive to the ecosystem, (3) improved understanding of how agroecosystems function, and (4) knowledge transfer among commodities and regions.

The transition from intelligent pesticide management to a more sustainable, ecologically based management system likely will accelerate in the future.

In conclusion, IPM can become more than intelligent pesticide management. The transition is underway in many systems both nationally and internationally. Intelligent pesticide management has been an important first and, in many ways, the easiest step in this transition. However, this approach, by itself, is not sustainable. To attain the goal of safe, economical, and sustainable food production, IPM programs need to move beyond the initial step of intelligent pesticide management toward more multitactic and ecologically based approaches to managing pests.

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Con Position

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Although critics negatively define IPM as nothing more than "intelligent pesticide management," we see intelligent pesticide management as a positive aspect of IPM. Intelligent pesticide management is a knowledge-based decision-making process that evaluates multiple risk factors associated with each potential pest management tactic, including pesticides, in designing the safest overall management strategy. IPM will not move beyond intelligent pesticide management in the foreseeable future because: (1) IPM is adaptable, focused on risk assessment, and supported by current government infrastructure, and (2) pesticides will continue to be an important component in the pest management arsenal.

A key concept in the IPM philosophy is that IPM programs are adaptable, allowing management strategies to evolve as new technologies develop, societal goals change, and risk assessment methodology improves. Although the history of IPM has been dominated by chemicals, IPM has moved away from traditional nonselective pesticides to safer, more target-specific pesticides and has encouraged a greater reliance on alternative management strategies (Benbrook et al. 1996, Calvin et al. 1995).

IPM emphasizes decision making based on risk assessment, which currently focuses on three primary types of risk (i.e., economic, human health, and environmental). To be acceptable to growers, the cost of pest management inputs must not exceed the economic benefits derived from their usage. The degree of risk acceptable to growers will depend on their economic position and ability to meet society's human and environmental health requirements, while maintaining a viable business. Although simple calculations of economic risk frequently favor pesticide use over alternatives, "intelligent pesticide management" also considers human health and environmental risks prior to finalizing a control strategy.

The impacts of pesticides on human health and environmental risk are assessed primarily by the Environmental Protection Agency (EPA) through the pesticide registration process. Additionally, agricultural products are monitored for pesticide residues during food processing and marketing by the manufacturer, the Food and Drug Administration (FDA), the EPA, and many private organizations to assure continued safety. Many alternative strategies (predators and parasitoids) are not subject to such rigorous monitoring despite the possibility of exotic control agents having unforeseen negative effects on native and nontarget populations (Collard 1996).

Finally, the term "pesticide," as defined under FIFRA as amended encompasses a large proportion of current management tactics. Under FIFRA, the term pesticide refers not only to synthetic insecticides but to many other kinds of chemicals such as attractants, insect growth regulators, pheromones, and even biological control organisms such as *Bacillus thuringiensis* (Berliner). Pedigo and Higley (1992) stated that it would be difficult to overestimate the importance of pesticides in the world production of food and fiber. These chemicals rank alongside medicines in their influence on our existence. Pesticides likely will not be eliminated from the pest control arsenal because they represent diverse products from a growing industry, are becoming safer, and, in many cases, are the least risky tactic in terms of economics and human and environmental health.

Because IPM is adaptable and emphasizes risk assessment, our current national infrastructure supports it. Competing philosophies have not addressed adequately the feasibility of implementation of their ideologies (National Research Council 1989, 1996), whereas IPM already enjoys widespread practical support among growers and the government. Non-IPM programs just cannot be substituted into a system that took over 40 years to develop and to be accepted by growers.

Because IPM allows flexible, dynamic strategies, it invites improvements in knowledge, technology, and risk assessment. It is better to allow change to occur within the established IPM framework than to establish non-IPM programs. We believe IPM cannot be more than *intelligent* pesticide management within the foreseeable future because: (1) IPM is adaptable, focused on risk assessment, and supported by current government infrastructure, and (2) pesticides will continue to be an important component in the pest management arsenal.

It is better to allow change to occur within the established IPM framework than to establish non-IPM programs.

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Topic

All Publicly Funded Research on IPM Must Focus Primarily on Multidisciplinary, Farm-Level Investigations

Background

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There is contention about how public funding for agricultural research should be allocated. Due to budget constraints, finding adequate public funding for any field of research, including agriculture, increasingly is becoming difficult. Therefore, there is a need to make the most efficient use of the funds that are available. Additionally, interest in IPM has spread from farmers and researchers to the general public. This has been driven by public concern over environmental quality, natural resource conservation, and food and worker safety. Increased public interest leads to increased public scrutiny as agricultural issues find their way to the evening news and popular publications. Given that these issues are in the public eye, the agencies that allocate taxpayers money may be held accountable for the impact of their funding decisions. Funding of projects, however meritorious, which appear frivolous to the public likely are to be challenged in this era of limited finances.

There is a conflict between those who favor multidisciplinary, farm-based research and those who lean toward basic research within individual disciplines.

The first large scale federal funding of agriculture occurred in 1887 with passage of the Hatch Act, which established the State Agricultural Experiment Stations at land grant universities. Over the next 70 years, subsequent acts and appropriations provided additional federal support. Recently, significant legislation has been enacted that impacts funding policies for agricultural research (Norton et al. 1995). Much of this legislation has been prompted by public pressure.

As early as 1972, thorough studies such as the Pound report (National Research Council 1972) concluded that agricultural research in the United States was of low quality. The design of the research system, including its patterns of funding and system of rewards, was blamed. The Pound report cited the focus on commodities and commercial interests as a weakness of agricultural research. These conclusions later were reinforced by the Rockefeller Foundation's (1982) Winrock report that linked the system of formula funding with the low quality of agricultural research.

Soon after the Pound report, Jim Hightower's popular book *Hard Tomatoes, Hard Times* (1973) helped spur intensive public debate concerning issues of agricultural research. Public pressure led Congress to enact significant agricultural legislation, notably the Food and Agriculture Act of 1977. This act changed the funding patterns of the United States Department of Agriculture's (USDA) Cooperative States Research Service (CSRS) by establishing the Competitive Research Grants Program. Prior to this program, most CSRS funds were allocated to the states by formula-funding based on land use patterns and population. The federal government placed few restrictions on how the funding could be used. Under the Competitive Research Grants Program, some federal funds can be obtained only on a competitive basis, often for study of narrowly defined problems. Research areas can be as specific as investigating the mode of action of a promising biological control agent. Additionally, both competitive and special grants obtained from Congress now are earmarked frequently for specific purposes (Smith 1995).

The Food, Agriculture, Conservation, and Trade (FACT) Act, passed in 1990, authorized the Sustainable Agriculture Research and Education (SARE) program. This required the CSRS and the Extension Service to develop sustainable agriculture research programs. FACT directed administrators of the National Research Initiative Competitive Grants program to emphasize what was described as mission-linked, multidisciplinary research. In addition, there was an emphasis on sustainable agriculture research and education.

The goal of mission-linked, multidisciplinary research has been hindered by a shortage of formula-funding for agricultural research. Federal formula-funding sources have not kept up with inflation, leading to greater dependence on competitive grants. Competition for grants from the federal government tends to discourage mission-linked research, as government agencies historically have funded basic over applied research. Funding for agricultural research also is provided by specific segments of the agriculture community such as commodity organizations, agribusiness firms, and various foundations. Research so funded tends to address specific problems of interest to the funding organization (Beattie 1980).

Whatever the funding source, there is the question of what research to fund. There is a conflict between those who favor multidisciplinary, farm-based research and those who lean toward basic research within individual disciplines. Proponents of basic science assert that without strong basic science, applied science becomes little more than repetitive testing of products and techniques. Applied science advocates contend that without strong applied research and development, basic science will not benefit society in general (Cole 1989). Traditionally, agricultural progress has stemmed from a synthesis of basic and applied research. Ideas and technologies move from the laboratory to field trials and, ultimately, to on-farm utilization.

Changes in funding patterns and public perceptions will have a significant impact on the future of agricultural research. The scientific community will be faced with difficult decisions in order to maintain the viability of both agriculture and agricultural science.

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Pro Position

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The federal government has set a goal of IPM implementation on 75% of U.S. farmland by the year 2000 (Browner et al. 1993). To achieve this ambitious goal, limited public funds must be committed more efficiently to accelerate the adoption of IPM. We propose that public funds earmarked for IPM research should be awarded only to projects that satisfy two criteria. First, appropriate disciplines must collaborate to integrate their respective pest management tactics into a feasible program for the target system. Second, this IPM program development must occur on the target site, on the farm. These criteria will ensure that the resulting programs are ready for implementation by the end-user.

IPM research is not successful until the resulting pest management program has been implemented. Unfortunately, universities traditionally address complex agricultural problems in small researchable units that can be examined by specialists in a variety of disciplines. Extensionists and farmers are left to make educated guesses about how individual management tactics will interact, and the farmers face risks that often prohibit them from trying novel combinations of pest management tactics. With publicly-supported IPM research focused on the compatibility of management tactics, much of the risk will be eliminated. Interdisciplinary research teams, including growers and extension personnel, will develop effective and feasible field strategies.

Incentives for collaboration across disciplines currently are insufficient (Chippendale 1996). In fact, university administrative policies often present roadblocks to long-term, interdisciplinary research (Burgess 1994). The push to secure tenure, promotions, and new funding sources drives academic workers to specialize on problems that provide quick results and produce more publications and marketable products. If funding were targeted specifically for interdisciplinary farm-level research, positive incentives for collaboration across disciplines would be created.

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Funding agencies also have failed in promoting interdisciplinary farm-level studies. Traditionally, the projects that receive funding are cost-effective, produce quick results, and are divided into easily defined research units. As projects become more diversified, it takes longer to get results, responsibilities of individual researchers are less clear, and the projects outgrow the budget ceilings of many funding sources.

When agencies do promote integrated on-farm investigations, the grants usually are viewed as niche rather than mainstream funding. As an example, SARE grants have been successful in promoting a limited number of integrated research programs (e.g., Anon. 1993, Holtzman 1994). However, because this funding is only a tiny portion of the federal pie, it does not provide an overriding incentive for researchers to design projects to fit SARE's goals. In principle, public funding agencies are in the unique position of being able to create positive incentives by pooling resources and collectively funding complex, large-scale, long-term investigations; in practice, however, this always has not been the case.

We are not suggesting that all agricultural research funding be subject to the multidisciplinary and on-farm restrictions that we propose for IPM funding. Single-component, basic-research projects often comprise the building blocks of an IPM program and should continue to be supported by sources such as the National Research Initiative grants, Federal Formula Funds (Hatch), and the National Science Foundation (Benbrook et al. 1996).

Pest management decisions on a given farm are shaped not only by the pest problems on the farm but also by the broader societal context in which the farmer lives and works.

In conclusion, we believe that the current system is not fostering the long-term, team research that is essential for broad-scale adoption of IPM. Our argument applies to all IPM implementation in agricultural, horticultural, and urban settings. The only way to enable researchers to undertake these highly important efforts within the constraints of their careers is to restrict public IPM funding to projects that truly are integrated and farm-level. If the government is at all sincere about its goal of implementation of IPM on 75% of U.S. farmland, our proposed funding policy is long overdue.

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Con Position

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There are flaws with the assertion that publicly funded IPM research should focus on multidisciplinary, farm-level investigations. The main problem is the assumption that IPM programs require information primarily on farm-level processes. Pest management decisions on a given farm are shaped not only by the pest problems on the farm but also by the broader societal context in which the farmer lives and works. Neither of these influences are limited primarily to the farm-level. Ecological processes that cause pest problems and affect IPM implementation operate at many levels and scales (O'Neill et al. 1986). Therefore research is needed on various levels. Although IPM research often focuses on biological and/or ecological processes related to pest problems, an analysis initiated by the EPA and USDA concluded that "constraints relating to policy and market were among the most serious constraints limiting the more wide-spread adoption of IPM" (Zalom and Fry 1992). Similarly, Raupp (1994) stated, "We need a broad research program that deals with fundamental agroecosystem processes, socioeconomic questions, appropriate livestock production systems, food quality, and information transfer among farmers and others." To encourage scientists to pursue answers to all questions important to IPM, public funding should be extended to relevant research at any level. Many such questions are central to the implementation of IPM but need not be addressed through multidisciplinary studies.

A second problem with restricting IPM research to farm-level investigations is the need for urban IPM. Publicly funded research should benefit the public. Less than 2% of the U.S. population now lives on farms. Urban and suburban populations must deal with pests in settings as diverse as households, workplaces, exterior and interior landscapes, schools, and hospitals. Urban dwellers want and need safe and effective methods of pest control in these situations.

Savage et al. (1979) found 90.7% of householders personally had applied pesticides–84.0% in their homes, 21.4% to their garden, and 39.7% in the yard. Extensive use of pesticides by inexperienced householders carries with it risks of misapplication and human exposure. Home gardening is one area of urban pest management that has benefited from IPM. This area has much in common with agricultural settings, and application of IPM can be transferred to some extent. However, application of IPM strategies to urban environments requires different approaches and information.

Household pest control is just beginning to adopt IPM strategies. Rust (1994) stated, "In recent years, the interest in utilizing IPM to control cockroaches has dramatically increased." Other arthropods of importance in urban areas include ants, structural pests such as termites, and health pests such as cat fleas, dust mites, mosquitoes, and ticks. IPM is needed for these pests as well. Unfortunately, there is little evidence that the special needs of urban IPM are being researched for the purpose of program implementation (Zungoli and Robinson 1984). Implementation of urban IPM is impossible without funding for research that addresses the special needs of urban settings.

In summary, publicly funded IPM research must include urban IPM, both to target a needed area and to maintain support by providing visible benefits to the public. In both urban and agricultural settings, studies to support pest management must examine diverse information needs, ranging from biology to economics to public opinion. Clearly, many of these needs are shaped by processes that operate at levels other than the farm or urban setting. Maximal adoption of IPM requires funding for studies in any relevant discipline and at any relevant level of organization.

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Topic

Restricted-Use Pesticides Should be Used Only with a Prescription by an Independent, Certified Crop Advisor.

Background

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Urban and suburban populations must deal with pests in settings as diverse as households, workplaces, exterior and interior landscapes, schools, and hospitals.

Legislation mandating a prescription from an independent, certified crop advisor before the application of restricted-use pesticides is a possibility for the future. Restricted-use pesticides, as defined by the EPA, are pesticides that may have unreasonable adverse effects on the environment, including injury to the applicator. Currently, each state has its own program, mandated by FIFRA, that certifies pesticide applicators (independent and nonindependent) to apply restricted-use pesticides. However, federal law does not require written recommendations before the application of restricted-use pesticides. If prescription legislation were enacted, certified pesticide applicators would no longer be able to apply restricted-use pesticides without first obtaining a written recommendation from an independent, certified crop advisor. To be considered independent, the crop advisor could not be affiliated with a company that sells the prescribed products. Such legislation would be analogous to regulations that require a prescription from a physician before certain medications can be purchased or used. In both cases, the assumptions are: (1) certain substances have sufficient hazards associated with their use that they should be used only under the guidance of someone with expert knowledge, and (2) persons recommending the use of such substances should not profit from the sale of those substances.

In anticipation of laws requiring prescription-use of pesticides, the Entomological Society of America convened a meeting of representatives from a select group of scientific societies (F. Knapp, personal communication). Two of the issues raised at the meeting were: (1) consequences of mandating prescription pesticides, and (2) pesticide prescriber qualifications.

...if people were to place too much faith in the ability of this law to protect them, they might not take the precautions they took...before the legislation was enacted.

The group considered several possible consequences of mandating prescription-use of pesticides. Potentially, prescription-use could preserve minor-use pesticides. Minor-use pesticides are used less widely than pesticides registered for use on major crops and pests and, therefore, do not generate sufficient sales to justify the time and expense for their registration or re-registration. Proponents of prescription-use of pesticides argue that prescription-use would ensure continued availability of these pesticides, but this outcome would require changes in pesticide registration policies.

Prescriptions could provide professional justification for use of restricted-use pesticides, thereby reducing the probability of misuse. Prescriptions also could function to preserve special-need pesticides that had been banned due to high levels of toxicity. Such pesticides then could be used under prescription in an emergency when more conventional pesticides were ineffective. On the other hand, laws restricting these pesticides could lose their significance if special-use permits were abused by prescribers. Thus, it is possible that prescription-use legislation may not change how restricted-use pesticides are used and therefore, may not lead to a reduction in their misuse.

Prescription-use legislation, if interpreted as more stringent regulation of pesticides, could reduce the public's concerns over pesticides. However, if people were to place too much faith in the ability of this law to protect them, they might not take the precautions they took with regard to pesticides before the legislation was enacted.

Finally, prescription-use legislation could increase employment opportunities for persons trained in crop and animal protection. Farmers, however, might have to bear the brunt of the cost for these services. These economic issues would need to be considered when drafting prescription-use regulations.

Participants at the ESA meeting agreed that standards for prescribers of pesticides should be based on education, experience in crop or animal protection, and certification by a recognized and accredited program. However, they recommended that the specific criteria for certification come from federal agencies as well as those who would be affected by the legislation, including farmers, crop advisors, certification organizations, and educational institutions.

California, the only state that currently enforces prescription-use, requires crop advisors to pass a written exam developed and administered by the California State Department of Pesticide Regulation (P. Marer, personal communication). If someone other than the farmer recommends a restricted-use pesticide, California law requires a written recommendation from a certified crop advisor before the application is made. This law was applied to commercial applicators and individual farmers in 1974, and public agencies in 1987. There are no crop-specific or site-specific limitations to California's law. Although the California law provides more stringent regulation of restricted-use pesticides than other states, it does not prohibit the use of pesticide prescriptions by nonindependent crop advisors, such as those employed by companies that sell the chemicals they prescribe. This creates a perceived conflict of interest. Except for not requiring prescribers to be independent, the California model is similar to the proposed legislation.

Allowing restricted-use pesticides to be applied only when prescribed by an independent, certified crop advisor surely would have profound effects on our agricultural community, where pesticides are used so extensively to control insects and other pests. The various consequences of this regulatory approach should be considered carefully when writing such legislation.

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We acknowledge the cooperation of F. W. Knapp (University of Kentucky), who provided information about ESA's meeting on prescription pesticides; and P. J. Marer (University of California Statewide IPM Project), who provided information on the regulation of restricted-use pesticides in California.

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Pesticide legislation has helped to make U.S. agriculture among the safest and most productive in the world. Recent passage of the 1996 Federal Food Quality Protection Act (FQPA) demonstrates continued public support for strong pesticide regulation. However, such legislation promotes restrictive measures for pesticide use rather than providing a regulatory structure to facilitate safe, effective, and economically feasible pest management strategies. As an example of the inadequacy of this legislation, federal classification of materials as restricted-use has not prevented their overuse or misuse (e.g., atrazine and alachlor) (Marer 1988, Metcalf 1996). An alternative to continued restrictive measures would be legislation requiring that restricted-use pesticides be used only when prescribed by an independent, certified crop advisor. No restricted-use materials could be purchased or applied without written prescriptions, a situation analogous to the regulation of controlled pharmaceuticals by physicians.

Under this system, prescribers would be highly trained and certified in pesticide application and pest, crop, and land management. Their responsibilities would include prescribing the most effective and safest compound at the appropriate time and maintaining records of these recommendations. Application records managed by prescribers would provide easy access to information for pesticide incident reviews and would provide a foundation for regional or national programs. These professionals would ensure safe and effective use of pesticides, increase public confidence in pesticide use, and reduce the need for complicated restrictive legislation that, otherwise, might hamper the adoption of new pest management technologies.

As early as the 1940s, the need for pest control specialists who would prescribe appropriate pesticide applications was recognized (Flint and van den Bosch 1981). This need has been met partially; in many production areas, pest management advisors are responsible for scouting and recommending pesticide applications. Indeed, in some commodities (e.g., tree fruits in the Pacific northwest, J. F. Brunner, personal communication), voluntary compliance with these recommendations is equivalent to mandated prescription-use of pesticides. The proposed prescription-use model can build on this infrastructure and be extended to all agricultural commodities.

A prescription program also will allow more effective and sustainable pesticide use. Specifically, prescription-use will facilitate selection of the most appropriate chemical, facilitate implementation of pesticide resistance management strategies, and foster area-wide pest management. Regional pest management will result in stable pest populations that are below economic injury levels (Pedigo 1996). To control pest outbreaks and to help extend the useful life of available chemicals, prescribers will be authorized to sanction some particularly hazardous pesticides on an emergency basis.

Prescription use of pesticides will have costs. These will include prescriber training programs, certification, and supervision, but these costs will be offset by improved production, fewer pesticide applications, increased employment opportunities, and fewer costly increases in pesticide monitoring. A reduction in the misuse of dangerous pesticides will manage pest populations proactively while ensuring the safety of food, humans, and the environment. The prescription of restricted-use pesticides is not only the most effective but the least costly of alternatives.

A reduction in the misuse of dangerous pesticides will manage pest populations...while ensuring the safety of food, humans, and the environment.

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We thank J. F. Brunner (Washington State University) for providing information on the relationship between crop advisors and pest management in tree fruits.

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Con Position

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When used correctly, the current system prevents overuse and misuse of pesticides.

Although most entomologists agree that reduction of pesticide use is of utmost importance, prescription-use of pesticides will not accomplish this goal. Rather, prescription-use represents policy fraught with uncertainties and adverse consequences that could cause serious problems for researchers, agricultural producers, and consumers.

Legislation mandating prescription-use of pesticides is unnecessary. Existing laws and agencies (e.g., FIFRA, EPA, FQPA) regulate pesticide applications effectively and ensure that Americans enjoy one of the safest food supplies in the world. According to the American Association of Poison Control Centers, there were 14 deaths due to pesticide poisonings in 1989, with only 2 being accidental; the rest were suicides (Litovitz et al. 1990). Considering that U.S. growers use approximately 705 million pounds of pesticides per year (Pimentel et al. 1991), it is obvious that the current system is working remarkably well. Further, newer insecticides that are being registered currently have increased target specificity and safety.

In many crop production systems, the equivalent of prescription-use is in place. The combination of pesticide labels, crop consultants, and economic thresholds serve as prescriptions. The label informs growers of legal use and application methods of pesticides. Crop consultants inform growers of the pest status of their crops using economic thresholds to avoid economic crop injury and unnecessary pesticide applications. Pesticide applications are costly, so it is in the best interest of growers not to spray them carelessly. When used correctly, the current system prevents overuse and misuse of pesticides.

Another problem associated with pesticide prescriptions concerns the qualifications of individuals available for these positions. Are individuals available with knowledge on many cropping systems and pesticide solutions to specific pest problems? If not, who will train them? Entomologists may feel comfortable making insecticide recommendations, but will they be qualified to recommend herbicides for weed management? Adequate training required to write prescriptions will necessitate field training before pesticide recommendations can be made for an array of cropping systems and pest complexes. Persons completing degrees in agricultural disciplines may be unprepared to meet these demands. The training required to keep prescribers familiar with many pest-crop interactions and control tactics could be phenomenal.

Some argue that implementation of pesticide prescriptions will increase employment opportunities. In fact, Higley et al. (1992) estimated that pesticide prescriptions would require "tens of thousands of certified prescribers given the vast acreage of agronomic crops in the United States." The availability of individuals qualified to meet such demands is questionable. People currently involved in pesticide sales and application may be qualified to write prescriptions, but the question of conflict of interest arises. However, without the involvement of pesticide salespeople and crop consultants, not enough prescribers will be available to meet the need (Higley et al. 1992).

The final and, perhaps, most important obstacle concerning pesticide prescriptions is cost. Governmental costs will include costs of program establishment, prescriber certification, training, and continuing education. Costs to governmental agencies will be passed on to taxpayers. Additionally, if growers are required to pay prescribers' salaries, this added expense will add to the economic hardships farmers face, particularly if crop subsidies are abolished. Additional costs of pesticide prescriptions could hinder U.S. farmers' global competitiveness seriously if other countries do not have to abide by the same regulations.

In summary, pesticide prescriptions are unnecessary, will require enormous amounts of personnel and training, and will reduce growers' control of their farming operations due to more costly government policy. This type of regulation does not enhance the adoption of IPM principles and could hinder what should be the primary objective of pesticide policy—the production of a bountiful, safe, affordable food supply in an environmentally acceptable manner.

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Topic

The 1996 Farm Bill Will Enhance the Long-Term Adoption of Ecologically Sound IPM

Background

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The 1996 Federal Agricultural Improvement and Reform (FAIR) Act was signed by President Clinton after the longest farm bill debate in U.S. history. Previous farm bills have been five-year bills, but FAIR is a seven-year bill and will be considered for reauthorization in the year 2002. Many of us who work in agriculture may be unaware of the importance of Farm Bill legislation, but FAIR significantly changes U.S. agricultural policy. Some of these changes will affect the practice of IPM.

One of the most significant changes in FAIR is the removal of government commodity price support payments to growers. These payments, called production flexibility contract payments, now will be paid in seven annual fixed but decreasing payments (Economic Research Service/USDA 1996). Growers will have greater flexibility in making planting decisions and still will be eligible to receive contract payments; however, they will have to rely more heavily on the market as a guide for production decisions.

With FAIR, originally introduced as the "Freedom to Farm" Act, growers can plant most crops on their base or contract acreages (with limitations on fruits and vegetables) with no loss in payments. To receive payments and loans on program commodities, they must enter into a "production flexibility contract" for the next seven years. These contracts will require them to comply with existing conservation plans for their farms. Exactly how this new flexibility and market reliance will affect IPM practices is unclear. Crop rotation may become more widely practiced. The reduction in subsidies could affect economic injury levels by putting pressure on growers to produce a more competitive product. Growers may be less inclined to use practices perceived as risky, yet they will be compelled to comply with conservation requirements.

Although crop supports will be shrinking steadily over the next seven years, conservation programs will be growing under FAIR.

Although crop supports will be shrinking steadily over the next seven years, conservation programs will be growing under FAIR. Indeed, FAIR will direct more money to conservation than has any farm bill in U.S. history (Baker 1996). The Natural Resource Conservation Service (NRCS, formerly known as the Soil Conservation Service) is the agency that oversees many of these conservation programs. The NRCS now has a broader mission, which includes wildlife management and clean water as well as soil conservation.

The 1996 FAIR farm bill extended several conservation provisions, including the Wetland Reserve Program (WRP), Swampbuster, and the Conservation Reserve Program (CRP).

The WRP is designed to return crop land that previously was wetland back to wetland (Lant et al. 1995). Growers who voluntarily enroll eligible acreage in WRP receive payments for permanent easements, 30-year easements, or restoration cost-share agreements. Swampbuster denies payments to growers who drain wetlands. The CRP pays farmers to take highly erodible or environmentally sensitive lands out of agricultural production.

FAIR also established The Environmental Quality Incentive Program (EQIP). EQIP provides technical, financial, and educational assistance to growers to address natural resource concerns (http://www. nhq.nrcs. usda. gov/OPA/FB96OPA/eqipQ%26A.html). Qualified growers are required to submit a conservation plan to the NRCS; private professionals, such as pest control advisors, can help growers develop their plans. Specific practices that will allow growers to qualify for EQIP will be identified by local work-groups, and such practices could include EBPM. For example, work-groups could decide to extend incentives established for growers in the 1990 FACT farm bill. Under that bill, growers of specialty crops were offered a $20 per acre incentive for up to three years if they reduced by 20% the pounds of active ingredient of pesticide per acre over that three-year period.

Finally, under the Research, Extension and Education title of FAIR, federally supported IPM programs will receive the same budget in 1997 as in 1996 (i.e., $50 million). A request for an additional $8 million to be used for research and extension competitive grants was denied (Anonymous 1996). The SARE program, established by the 1985 farm bill, received a 10% increase in funding, which still represents less than 1% of the total USDA research budget.

In conclusion, the 1996 FAIR farm bill decreases subsidies for farmers while increasing payments for conservation programs. Flexibility is a key theme in the 1996 farm bill—flexibility for farmers to choose what they will grow and how they will grow it.

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Pro Position

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...IPM could play a large role in replacing farm income lost from price support payments by reducing production costs.

Seven years from now, farmers will be financially independent from the government. This will be a noble thing, a return to Jeffersonian liberalism. The 1996 FAIR farm bill's elimination of producer support payments dependent on the agricultural base, production, or price will create an independence not known by this generation of farmers. Before FAIR, farmers could farm as they pleased, knowing that the government would supply them with a profit in the form of a crop price-support check. However, without government support to save them if their production costs are close to the crop's value, producers will have to take all possible measures to maximize net profits. Because IPM is the optimization of pest control in an economically and ecologically sound manner (Office of Technology Assessment 1979), IPM is the strategy that farmers will use to maximize net production and/or profit. Hence FAIR will enhance the long-term adoption of EBPM.

In 1987, net farm income in the United States was approximately $46 billion, while direct government payments were approximately $16 billion or about 25% of the average farm family's income (USDA 1987). Over the next seven years, these government payments will drop steadily to zero. Given that IPM is the optimization of both economic and ecological management practices, IPM could play a large role in replacing farm income lost from price support payments by reducing production costs.

Several provisions in FAIR will enhance adoption of EBPM. EQIP will provide financial assistance to farmers who adopt IPM as part of their overall conservation practices. USDA's Natural Resources Conservation Program (NRCP) will evaluate on-farm conservation programs submitted by both farmers and private consultants. Once accepted, the NRCP will provide a $20 per acre incentive to reduce pesticide use by 20%. Varietal selection and cultural practices will reduce the use of fungicides and herbicides in this same rudimentary IPM program. These benefits will contribute to the long-term adoption of IPM.

An IPM program begins by assessing the pest problems associated with a crop and its production unit. The economic effect of each pest in the system is usually the easiest and quickest factor to evaluate, and this should be the first completed. Control tactics such as selection of resistant varieties, adjustment of planting date, planting density, harvest date, destruction of crop residue and volunteer plants, irrigation management, weed control, tillage, and other cultural practices are selected on the basis of their cost-benefit ratio. The last tactic to be integrated into an IPM program should be chemical control. Chemical control of insects and mites should be seen not as a preventative measure but as a therapeutic measure used to lower a pest population below its economic threshold. True economic thresholds are based, in part, on the value of the crop for that season, usually unknown, combined with the cost of control, which usually is known. With the loss of support payments, the producer is even more uncertain than in the past about the crop's value and so must do everything possible to reduce production costs. IPM will lower production costs and, therefore, will be adopted by producers.

In conclusion, there are several reasons that the 1996 FAIR farm bill will enhance the long-term adoption of EBPM. First, the farm bill eliminates production-based support payments and all types of payments within seven years. IPM programs adopted during this transition period will continue long after the support payments have ended. Second, many incentives are in place to encourage adoption of EBPM programs. Finally, because pesticides should be the last component added to an IPM program, and used only in combination with an economic threshold, IPM programs inherently are sound ecologically. In addition, the use of economic thresholds works to optimize net yields and farm profits. These factors will motivate farmers to maximize their profits through the long-term adoption of IPM.

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Con Position

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The 1996 FAIR farm bill, in certain aspects, is "fairer" to farmers than were previous farm bills. Many farmers now have the freedom to sow their crop of choice for the next seven years without losing support payments. However, the debate at hand is whether FAIR will attend to one particular aspect of agricultural production—ecologically sound IPM. What exactly is ecologically sound IPM? The National Research Council provides a broad definition in its recent book *Ecologically Based Pest Management* (National Research Council 1996). The council states that EBPM is the use of those strategies that "maintain the ecological balance of the region and the natural balance of agricultural pests and their enemies." EBPM relies explicitly on a thorough knowledge of pest biology and the interactions of the pest with physical and biological components of the farm. Fundamental to EBPM are farmer profitability, public safety, and durability. For the remainder of this paper, we will use "EBPM" synonymously with "long-term ecologically sound IPM."

Many farmers now have the freedom to sow their crop of choice for the next seven years without losing support payments.

To distill the issue of what FAIR will do for EBPM, two questions must be answered: (1) what approaches actually have enhanced the adoption of EBPM? and (2) what does FAIR do to promote or support these approaches? To answer the first question, an examination of particular programs and organizations that successfully have demonstrated the viability of EBPM is necessary. The SARE Program, for instance, initiated in 1993 a successful program in California that involved farmers, local pest control advisors, and various agricultural specialists. The program, termed Biologically Integrated Orchard Systems, was to have on-farm research generate tangible results and then hold "field days" to educate local, interested farmers. Nationally, over 1,200 farmers and ranchers have been involved in similar SARE research projects (Schaller 1994).

Another organization, The Leopold Center for Sustainable Agriculture in Ames, IA, is supported in large part by the taxation of agrichemicals. Over the past nine years, the Center has invested $2 million in research and education to encourage Iowa farms to adopt EBPM (Keeney 1996). The Center's research ranges from biological control of corn pests to reduction of farm runoff. Its work involves and directly benefits Iowa farmers; however, adoption of EBPM in Iowa has been slow. Much of the difficulty is attributed to the fact that EBPM strategies generally do not produce patentable techniques or profit-generating products (Keeney 1996). Without patentable or marketable products, the private sector is unlikely to support EBPM research. EBPM is inherently a process of maximizing on-farm resources and minimizing external inputs; the lack of distinct, patented EBPM products underscores the importance of public funding earmarked specifically for development and outreach of EBPM strategies.

Without patentable or marketable products, the private sector is unlikely to support EBPM research.

What does FAIR do to support, emulate, or further the work of such promising organizations? FAIR sets forth no new policies nor does it increase funding for programs or organizations working on EBPM; therefore, it is unlikely that FAIR would enhance the long-term adoption of EBPM. FAIR does allocate $130 million to the USDA for IPM research and education. However, this appropriation has been capped at this level since 1994. For fiscal year 1997, the USDA sought funding increases of $14 million for the IPM initiative and $33 million for the competitive research grants program, but both were denied by FAIR (Benbrook et al. 1996). SARE efforts are hampered seriously by federal funding deficiencies (Schaller 1994). Keeney (1996) noted that until policy makers acknowledge the significance of EBPM, such strategies will "languish for lack of funding."

Given the freedom afforded by FAIR for farmers to plant whatever crop they want, and without adequate incentives to do otherwise, it is likely that most farmers will embrace their most profitable crop and streamline their monocultural production efficiency. The reason is simple—"the agronomic and pest management benefits from more diverse rotations are likely to be outweighed by the economies of scale associated with highly specialized machinery and marketing infrastructure" (Benbrook et al. 1996). Indeed, FAIR will change farming in the United States, but it will not enhance the long-term adoption of ecologically sound IPM.

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Leslie L. Allee completed her Ph.D. on the management, ecology, and behavior of the western corn rootworm in August, 1997, with Paula M. Davis. Jennifer Altre is a Ph.D. candidate studying fungal infection of diamondback moth with John D. Vandenberg. Vonny M. Barlow completed his M.S. with Larry D. Godfrey at the University of California, Davis and has begun Ph.D. studies on biological control of leafy spurge with David J. Kazmer at the University of Wyoming. Robert L. Bossard completed his Ph.D. studying insecticide resistance in cat fleas with Alberto B. Broce and Michael W. Dryden. James F. Campbell is a Ph.D. candidate studying insect-parasitic nematode behavioral adaptations for finding and infecting hosts with Harry K. Kaya. W. Bruce Campbell is a Ph.D. candidate studying pattern and scale in ecology and the use of aquatic insects in stream bioassessment

with Merlyn A. Brusven. Yi Chen is a Ph.D. candidate studying the physiology and molecular biology of parasitoid/host interactions with John J. Brown. Jody L. Gangloff is a Ph.D. candidate studying population dynamics of onion thrips in onions with Michael P. Hoffmann and Charles J. Eckenrode. Carolyn J. Garvey is a M.S. candidate studying the effects of sweet corn maturation date on pests of corn with John L. Wedberg. Greg Godwin is a Masters of Agriculture candidate studying greenhouse biocontrol with Edwin G. Rajotte. Jennifer Grant is a Ph.D. candidate studying interactions of entomogenous nematodes and scarab grubs with Michael G. Villani. Harry Howell is a M.S. candidate studying urban entomology with George L. Teetes. Naomi Lovallo is a Ph.D. candidate studying the physiology of parasitism with Diana L. Cox-Foster. Craig S. Martin received his M.S. degree in August, 1997, after studying medical entomology under the direction of C. Lamar Meek. He is now employed in the Air Quality Division of the Louisiana Department of Environmental Quality. Roseanne N. Mascarenhas completed her Ph.D. in December, 1997, under the direction of Professor David J. Boethel. She is now employed by Zeneca Ag Products at Rocky Mount, North Carolina. Victor J. Mascarenhas completed his Ph.D. in December, 1997, under the direction of Jerry B. Graves. He is now employed by Zeneca Ag Products at Rocky Mount, North Carolina. Holly J. Mayland is a M.S. candidate studying the response of predatory mites to herbivore-induced plant volatiles with David C. Margolies. Pete McGhee completed his M.S. studying the biology and management of pentatomids in pome fruit orchards with Jay F. Brunner. Chris Nobbs is a M.S. candidate studying the biological control of tortricid leafrollers and alternative hosts of *Colpoclypeus florus* with Jay F. Brunner. Rita Rio is a M.S. candidate studying biological control with E. Alan Cameron. Paul S. Robbins is a Ph.D. candidate studying sex pheromones and mating systems of May and June beetles with Michael G. Villani. Deana Sexson is a Ph.D. candidate studying resistance management in transgenic crops with Jeffrey A. Wyman. Rebecca R. Smyth is a M.S./Ph.D. candidate studying oviposition preference of *Crocidolomia binotalis* for improvement of trap cropping strategies for this pest in Southeast Asia with Michael P. Hoffmann and Anthony M. Shelton. Shawn A. Steffan completed his M.S. studying the effect of habitat manipulations on biological control in *Brassica* systems with Daniel L. Mahr. Kimberly F. Wallin is a Ph.D. candidate studying host plant acceptance behavior in *Ips pini* and *Dendroctonus rufipennis* with Kenneth F. Raffa. Paul Whitaker is a Ph.D. candidate studying the effect of habitat modifications on biological control in apple orchards with Daniel L. Mahr. Lynn Wunderlich completed her M.S. working on a novel liquid release technique for delivering eggs of the green lacewing with D. Ken Giles.