All trees were on 'Troyer' rootstocks. The trees were field-grown in soil infested with *Phytophthora parasitica* and *P. citrophthora*, then budded to the selected cultivar, and, when large enough, transferred to 51-cm (20-inch) boxes containing infested soil from the same site.

The trees were watered by drip irrigation with two emitters per box. Each tree received 10 minutes of irrigation every three days and was fertilized with a complete fertilizer plus trace elements administered through the drip system. All trees used in the trial were selected for the presence of *Phytophthora* root rot symptoms, including small or chlorotic leaves, poor general growth, some defoliation, and sparse, rotting roots.

The study included a total of six treatments: four fungicide treatments applied every other month, a monthly water drench, and a nontreated control. All orange treatments were replicated eight times except for the water control, which had seven replicates. All grapefruit treatments were replicated three times except for the water control, which was replicated four times.

Metalaxyl was applied at a rate of 5.3 ml (0.18 fluid ounces) per container and fosetyl-Al at 12.6 grams (0.44 ounce per container. Treatments were either spread evenly over the container and watered in with enough water to reach the bottom of the container (broadcast), or divided into two equal portions and placed under the two emitters in each box (emitters). The monthly water drench consisted of adding water to the top of each box until it flowed freely from the bottom. The nontreated control received water according to the nursery's irrigation practices.

We collected data on rootstock and scion diameters, rated the dead branches present, made an overall visual rating, and counted *Phytophthora* propagules. At the time of the final evaluation, there were no significant differences in rootstock diameters. We observed differences in scion diameters, dead twigs, visual ratings, and *Phytophthora* populations (table 1).

The results indicate that both fosetyl-Al and metalaxyl fungicides were similar in performance with only minor differences. These differences were due to the mode of application, tree cultivar, and statistical significance level used. Both fungicides were consistently superior to the nontreated and water controls. Fosetyl-Al is not presently registered for this use in California, but metalaxyl does have registration.

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Attitudes about pesticide safety

Glenn R. Hawkes □ Martha C. Stiles

Citizens and specialists differ in their views of risks and benefits

Since 1980, infestations of the Mediterranean, Mexican, Caribbean, and Oriental fruit flies, the gypsy moth, and the Japanese beetle have represented potential economic losses to California's agricultural, floral, and forest industries. These infestations have occurred in densely populated areas (Los Angeles and the Santa Clara Valley), exacerbating problems in developing eradication strategies.

After considerable debate about the political, environmental, health, and economic implications of urban pest eradication, the California Department of Food and Agriculture (CDFA) began aerial and ground application of pesticides for some insects, such as the medfly and Mexican fruit fly. These eradication measures led to public discussion, scientific dispute, and, in most instances, community dissent. Past research indicates that, as uncertainty about the consequences of an action increases, so does anxiety, and so this conflict was predictable. The use of pesticides alone is often enough to stimulate community concern, and the use of aircraft in densely populated areas caused enough uncertainty to generate alarm.

Debate among scientists and government entities about risks associated with pesticide use in these situations heightened community apprehension. Such disagreements among specialists, as well as differences between the public and the experts, have been viewed as misinformation or miscommunication, rather than as the cause of community apprehension.

We compared risk perceptions of five groups of specialists with those of citizens involved in the California pest eradications. This study identified beliefs about pesticide safety, fundamental agreements and disagreements on risk and safety.

Behavioral science research on risk has explored social, demographic, and situational factors of individual events that influence how the public responds to risk. Studies have shown that sex and age differences affect risk perception. Education, proximity to the threat, whether or not exposure is voluntary, and perceived benefits are also influences. The amount of media coverage and its ideological emphasis contribute to changes in the perception of a threat. Others have discovered that differences in attitude are primarily due to the previously formed beliefs of various subgroups in the population about the risks and benefits of specific technologies.

One limitation of the research to date is the scarcity of information on perceptions, beliefs, and attitudes of the decision-makers involved in hazard management and risk analysis. Some such studies suggest, however, that scientists, government regulators, and other experts who implement technologies like pesticide use are subject to the same biases as citizens. Well-versed experts use the same mechanisms as the less knowledgeable public in responding to risky events. Past research suggests that specialists in, for instance, pesticides have a significant bias in favor of chemical use. This positive predisposition has been used to explain specialists' aversion to opposition and special-interest groups. We attempted to identify additional factors influencing polarization of

	+ High risk	− Low risk
− Low acceptability	Public interest groups Elected leaders General public	
+ High acceptability		University scientists Government administrators Applicators

Fig. 1. Scientists and others dealing with pesticides and eradication programs were usually on opposite sides from public groups in risk perception but differed among themselves as frequently as they did with the public about pesticide safety, risks, and benefits.

experts, citizens, and special-interest organizations embroiled in controversy.

The study

Two independent samples were drawn to represent the general public and pesticide specialists. The public sample was systematically drawn from four California city telephone directories: Stockton, Milpitas, Orangevale, and the Concord/Clayton area. Each community had been involved in a state pest eradication program: Stockton and Milpitas received aerial and/or ground sprays for medfly; Orangevale was treated by ground crews for Japanese beetle; and the Concord/Clayton area was sprayed by ground rigs for gypsy moth.

Eligible participants in the study were identified by trained interviewers, contacted by telephone, and asked if they would receive, complete, and return a mail questionnaire. Those in Orangevale received the questionnaire by mail without initial telephone solicitation. A combined total of 506 Californians responded.

To obtain the stratified specialist sample, we specified three characteristics, one or more of which were required for becoming a participant: (1) policy making or implementation of eradication projects and pesticide regulations; (2) research or scientific advisement on agricultural issues related to pesticides; (3) technical aspects of chemicals, such as spraying or other modes of application. Most of the specialists were in the 20 California counties identified by the CDFA for this project as having experienced infestations or special insect problems.

Specialists were subdivided into five groups for analysis: (1) elected leaders (city, county, state); (2) government agency administrators (county, state, and federal); (3) users and applicators (growers, production consultants, chemical representatives); (4) selected university scientists (entomologists, toxicologists, county extension advisors, and the like); and (5) public interest groups. This sample was systematically drawn from directories and other available listings.

Elected leaders included city council members, county supervisors and state legislators. Government administrators responded from CDFA, County Agricultural Commissioners, California Department of Health Services, and the U.S. Department of Agriculture. University scientific experts for the most part came from the University of California, including Cooperative Extension. Applicators were selected from membership rosters from the Council of California Growers, Western Agricultural Chemical Association, and California Agricultural Production Consultants Association. Among public interest groups receiving the questionnaire were the Sierra Club, California Agrarian Action Project, and Orangevale Action Group.

In addition to demographics, the questionnaires addressed risk, acceptability, benefits, costs, and level of trust in hazard management agents. Scales were constructed by adding scores across each individual variable for both samples.

The public sample was 54 percent male, average median age was 46 years, and average education was 14 years. Politically, 18 percent described themselves as liberal, 56 percent moderate, and 26 percent conservative.

Eighty-three percent of the specialists were male, with an average age of 46 years, and an average education of 17 years. Political moderates also dominated this sample (55 percent); 31 percent described themselves as conservatives; liberals, again, were in the minority (14 percent).

To examine beliefs about pesticides, we used a statistical method (one-way analysis of variance, ANOVA), which identified differences and similarities between the public and specialists. Differences were significant on all five measures — risk, acceptance, benefits, costs, and trust. Excluding the public, differences among the five specialist subgroups were also significant. Those involved in agricultural issues through government, industry, or university had little in common with those not having close ties with agriculture (public interest groups, politicians, citizens). Results describe differences between the general public and each of the five subgroups. We compared all six groups (including the public) to show direction and degree of response to individual items.

Risk and acceptability

Respondents described levels of agreement or disagreement with five risk and five acceptance questions. To arrive at a risk scale, we asked participants to evaluate the level of perceived harm or safety: in ground and aerial spraying; in home use; to agricultural field workers; to city and farm dwellers; and in agricultural use and use against neighborhood pest infestations.

Risk acceptability was defined as the public's willingness to endure or accept the risk of the chemicals. The questionnaire for the specialist groups was reworded to ask the degree of risk specialists expected citizens to accept. This was measured by responses on desirability of continuing extensive use of the chemicals and preference for more benign pest control methods, as well as a direct report of risk level the public should tolerate. All but elected leaders differed significantly from the public in perception of pesticide risk ($p<.01$). To determine the direction of response of all groups we obtained a ranking of risk levels from the most to least risk averse. Since the public and elected leaders essentially agreed, as did government and university specialists, four levels of risk perception emerged. From (1) greatest to (4) least risk averse, the ranking is as follows: (1) public interest groups, (2) elected leaders and the public, (3) university scientists and government administrators, and (4) applicators.

Applicators and public interest groups represented the two extreme views, the former perceiving minimal risk. Government and university respondents fell on the low to moderately low end, but were significantly more risk averse than applicators ($p<.05$). Public interest groups were polarized to the far side of perceived maximum risk. Elected leaders and the general public were on the high to moderately high risk end, but were significantly less risk sensitive than public interest groups ($p<.05$).

Significant (ANOVA $p<.01$) variations between all specialists and the public were found on levels of acceptance. Rankings of acceptance were the direct opposite of the risk scale, with applicators expressing highest acceptance and public interest groups the least. Those displaying high risk levels had little risk tolerance. This means that applicators, scientists, and government agencies expected the public to be more accepting of pesticide risk than the public actually was. Conversely, public-interest and elected leaders said citizens should tolerate substantially less risk than the public said was acceptable.

Individual items reveal where major variations occurred. For example, with regard to perceived pesticide safety in homes as opposed to agricultural use, a majority of citizens (59 percent) believed they, as home users, were very safe in applying pesticides, yet 61 percent feared that agricultural field workers were at risk in using the chemicals. Of the applicators, however, 97 percent were certain that neither home users nor agricultural field workers were at risk. More than 80 percent of the scientists and government administrators were also confident about the safety of pesticide use. Elected leaders' responses on safety of home users (60 percent) as opposed to agricultural field workers (54 percent) were similar to those of citizens. Less than half of the public interest respresentatives felt that either user group (home or agricultural) was safe.

All groups felt that ground application of pesticides was safer than aerial spraying on farms, except applicators, who considered both methods 100 percent risk-free. Similarly, a sizable majority (82 percent) of government administrators and university specialists rated the two application methods as essentially nonhazardous. Conversely, barely half of the general public and elected leaders, and fewer of the public interest groups (33 percent), viewed air or ground spraying on farms as safe. Asked about aerial application in cities, the public and elected leaders reported the potential for harm as three to four times greater than did applicators, government officials, or university scientists. Public interest respondents (92 percent) were extremely wary of using aircraft in urban areas.

Acceptability responses varied just as much. When asked directly if the public should be willing to accept the dangers of pesticide use, 80 percent of the public interest groups, 61 percent of the public, and 58 percent of elected leaders said no. On the other hand, applicators (90 percent), university specialists (70 percent), and government administrators (66 percent) said yes, citizens should be willing to accept the pesticide hazards.

Acceptance tends to increase when an apparent benefit accompanies pesticide use, such as eliminating insects in food. When asked if the public should be willing to eat insect-free food sprayed with the pesticides, most citizens (77 percent) and university scientists (79 percent) said yes. Government (93 percent) and applicator groups (98 percent) expected even greater citizen willingness to consume sprayed food. On the other hand, few of the elected leaders (49 percent) and public interest groups (27 percent) felt citizens should be willing to eat the food, insect-free or not.

Remove the easily perceivable benefit of fewer insects, yet maintain the activity of treating cropland, and acceptance drops dramatically. Respondents were asked if citizens should feel safe living next to crops sprayed with pesticides. A majority of the public (68 percent) and elected leaders (58 percent) found this risk of exposure unacceptable, as did public interest groups (91 percent). Applicators (94 percent), administrators (91 percent), and university specialists (69 percent) expected high public acceptance, greatly exceeding the citizens' expressed level of tolerance.

The proposition of extensive and continued agricultural pesticide use yielded similar reactions. Most applicator (99 percent), government (95 percent), and university (93 percent) respondents believed that continuing extensive use of the chemicals in California agriculture is necessary. A lesser majority of citizens (57 percent) and elected leaders (67 percent) acknowledged the necessity of continuing chemical use. Less than 40 percent of the public interest groups agreed. Even though agricultural chemicals were seen as necessary, a majority of respondents (except applicators and government administrators) considered biological methods as preferred alternatives. Less than 50 percent of applicators and government respondents agreed to the biological alternative.

Costs and benefits

Perceived qualitative gains or losses of an activity such as pesticide use are known to influence attitudes toward risk and acceptability of that risk. Specialists and citizens were presented costs and benefits and asked to assess the likelihood that each would result from using the chemicals. Responses closely patterned rankings on the risk-acceptability scales. Those perceiving low cost and high benefit were applicators, government administrators, and scientists. Public interest representatives, citizens, and elected leaders saw high cost and low benefit, attributing more losses than gains and a greater magnitude of loss, and tending to be more concerned about damage to the environment and threat to humans than did the other three groups. Applicator, university, and government respondents expected fewer costs overall from using pesticides and saw regulatory and bureaucratic costs as most severe.

Citizens, public interest groups, and elected officials considered air and water pollution the greatest cost, and unanimously ranked endangerment or loss of human life the second greatest cost. Low-risk, low-cost groups (applicators, government, and university) rated "increasing dependency on special groups" as the number one penalty of agricultural chemical use. High cost of government bureaucracies and pollution come in second and third, respectively, according to applicators and government officials. University scientists chose pollution and harm to humans as the most likely second and third costs.

On the benefit scale, elected leaders this time aligned themselves with applicators, government officials, and university specialists. They were notably ($p<.01$) more optimistic about the positive consequences of pesticides than were the public and the public interest groups. These last two agreed on overall level of benefit, as they did on overall cost. Government and university specialists were in agreement on the number and type of benefits.

Groups seeing little risk and few qualitative costs to pesticide use also expected greater benefits. An anomaly is that citizens agreed with applicator, government, and university subjects that high-quality food was the foremost benefit. Even though the ranking was the same, the magnitude was very different. For example, over 95 percent of those three specialist groups agreed on better food, but only 63 percent of the public agreed. Better food was ranked second by public interest groups and elected leaders.

Public interest groups, elected officials, and university scientists believed the increase in the economic well-being of all (consumers, chemical companies, and agribusiness), was the number one benefit. Economic well-being ranked second among government administrators and applicators, while university scientists saw economic well-being and better food as equal benefits. Public interest respondents and elected officials felt chemical

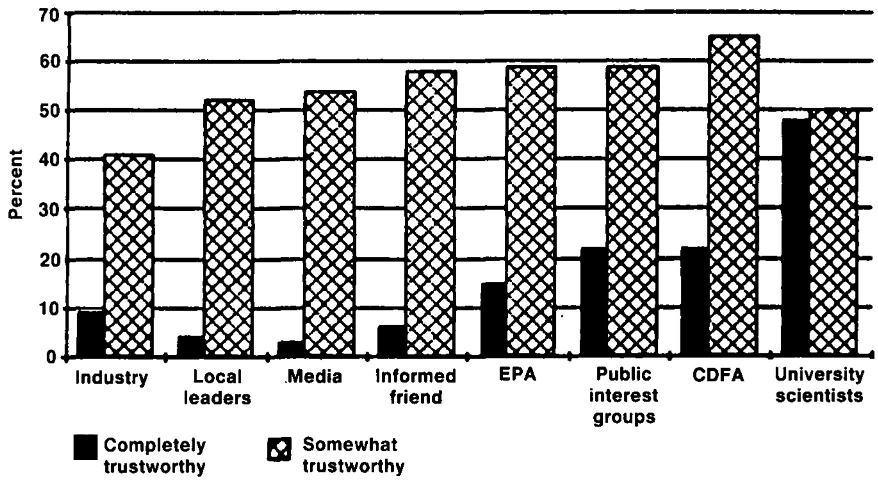

Fig. 2. University scientists ranked highest in a measure of the public's level of trust in various agents (levels based on percent in agreement).

companies were the primary beneficiaries. Government administrators viewed chemical companies and the public as equally benefiting. Increased employment was ranked high by 92 percent of the applicators, 81 percent of both the government administrators and scientists. Fewer members of the general public (58 percent), elected officials (57 percent), and public interest groups (33 percent) felt that use of chemicals reduced unemployment.

Who trusts whom

Perceptions of risks, benefits, and costs can influence public confidence in organizations and industries involved with hazard management. Trustworthiness reflected reliability and accuracy of information available to assist in protection or to communicate the level of hazard. Citizens and specialists assessed how trustworthy or reliable certain groups would be during an event in which public protection was a major issue.

University scientists were trusted most completely by the general public (fig. 2). Citizens trusted state agencies, like CDFA, as much as they did public interest groups, second only to university experts.

Most specialist groups rated themselves as the agent they would trust most in hazard management situations. Like the public, elected officials said university scientists should be trusted most, and placed themselves as one of the last they would trust as an information source. Even though public interest groups trusted their own people more than others, only 23 percent of this group trusted themselves completely. The only other specialists they had total trust in were university scientists (15 percent showing complete faith). State organizations (CDFA) listed themselves as equally reliable as university scientists; applicators trusted state more than university people.

None of the low risk, high-acceptance (applicator, government, and university) groups considered public interest representatives as completely trustworthy. State institutions reported the highest overall confidence in public interest groups. This is ironic in light of the historically adversarial relationship between public interest groups and government officials.

Media (TV, newspapers, radio) received the lowest score. No one in the specialist samples indicated "complete faith" in this group. The general public trusted only about 3 percent of media messages.

Conclusions

Variations in public and expert risk perceptions have been attributed in the past to influence of: (1) previously existing belief systems of each group; (2) orientation of training and education of respondents; and (3) miscommunication or misperception of data by the public. The present study in part supports these notions. First, the groups studied here did maintain diverse beliefs about pesticides. Second, groups with similar orientation of training and education tended to cluster along the same side of risk-acceptance, cost-benefit scales. Third, even though (mis)perception or (mis)communication of information was not directly measured, responses indicated decision-makers and citizens had different expectations of the outcomes of events. This difference may be due to the belief differences or to some parties not having accurate information. Variations in performance of specialist groups and the public were also clearly manifested.

Scientists and other specialists dealing with pesticides and eradication programs differed among themselves as frequently as they differed with the public about substance and application safety, who should incur risks, and what the benefits are. The public, elected leaders, and public interest groups tended to cluster together and view pesticides as a high-risk technology, at the same time recognizing the benefit and the need to continue use. Clustering to the opposite side were those intimately involved in agricultural issues and eradication programs. Government administrators, university scientists, and applicators considered agricultural chemical use as low risk.

Those perceiving high risk were less willing to accept the attendant hazards of pesticides than the low-risk perceivers, who scored high on acceptance. Those believing there were greater costs to pesticide use also believed there were fewer benefits. High-cost groups also had high-risk, low-acceptance levels.

Applicators and public interest groups were always at the extreme opposite ends of all scales, and their response levels were consistently dissimilar to those of all other respondent groups. Government administrators and university scientists were similar in their views of risk and acceptance, as were elected leaders and the public. Even though the general public was willing to accept more risks than public interest groups and elected leaders wanted them to, agriculturally oriented groups (applicators, government and university) expected even greater risk tolerance from citizens.

Trust in hazard management entities reflects public expectations of the performance of those decision-makers and specialists. Citizens expected the highest level of participation and quality of information from university scientists and the lowest from the media. This is an important finding since citizens receive most of their information from television, newspapers, and radio. Citizens expected the same performance or quality of information from public interest groups and state agencies. Most specialists (except elected leaders) viewed their own agency as most reliable in protecting the public.

Citizens and others in opposition to spraying pesticides have been described by some specialists as misperceiving the situation, which is then offered as the explanation of ensuing conflict. In this study, decision-makers and citizens have expressed basic, firm, and diverse beliefs about pesticides, which may create or enhance misperception or miscommunication between groups.

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