WORST FIRST:

High-Risk Insecticide Uses, Children's Foods and Safer Alternatives

Consumers Union of U.S., Inc.
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Foreword

Two years ago, the Food Quality Protection Act was passed unanimously by both houses of Congress. The law imposes much stronger standards for protecting public health from hazards of pesticides in foods, and puts special emphasis on ensuring that pesticide residues are safe for infants and children and other especially vulnerable groups.

The FQPA also calls for scientific, risk-based regulatory decision-making and priority-setting, reforms long sought by pesticide makers and users, and the law had widespread support when it was passed. But now, as the U.S. Environmental Protection Agency begins seriously implementing the FQPA, the economic interests affected are fighting back. The pesticide industry has mounted a well-financed, coordinated publicity and lobbying campaign designed to stir up political opposition to the FQPA, to prevent or delay EPA decisions that would ban or strictly limit many pesticide uses that contribute to children's overall exposure and risk.

The theme of the anti-FQPA campaign is that EPA is planning to ban entire categories of important insecticides, leaving farmers with no tools to manage insect pests. Scary publicity has magnified legitimate anxieties to panic proportions, and generated a political backlash that has already slowed the implementation process, and may threaten to derail it entirely.

This report seeks to ground the debate in some essential facts. First, there is no question that exposure to insecticides in foods needs to be reduced: The National Research Council and others have shown convincingly that current exposure levels are not safe enough for infants and children. Second, EPA need not impose draconian bans to achieve big reductions in risk: Selective actions can reduce risks substantially and soon, if the agency focuses on highest-risk pesticide uses. Finally, bans or severe restrictions on selected high-risk insecticide uses will not cripple agriculture: There are many viable alternatives growers can use to manage crop pests.

<u>Worst First</u> identifies 40 specific insecticide uses on nine fruit and vegetable crops that, together, account for a very large portion of kids' overall dietary insecticide exposure and risk. Our "Worst 40" uses should be high-priority targets for EPA action under the FQPA's "worst first" mandate.

If EPA eliminated the "Worst 40" insecticide-food combinations identified here, we estimate that the risks associated with insect pest management on the nine crops involved, which are foods children eat a great deal of, would decrease by about 95 percent. The FQPA will ultimately require more than these steps to reduce risks from pesticides in food, but focusing initially on the Worst 40 insecticide uses will effectively advance the public-health goals of the Act, and will also constitute "smart regulation," based on objective data and sound risk-management priorities.

Worst First presents our main findings and recommendations, and briefly describes the analyses we conducted. Our full analysis was more detailed and complex than we can describe here. We will make it available on our project web site (http://www.ecologic-ipm.com) by the end of September. We welcome communications from those interested in methodological issues or in carrying the analysis on to a higher level.

Later this fall, we will present another report, now in preparation, that lays out in detail the distribution of risks associated with current insecticide use patterns, and projects how a sound regulatory strategy under the FQPA can effectively drive down risk, without damaging agricultural productivity.

For now, we call on all the stakeholders in the FQPA process to stop their political posturing, to resist panic, to roll up their sleeves and get on with the hard work. Let's all start with the facts of pesticide use and risks, and begin to craft mutual strategies for reducing the risks to socially acceptable levels while preserving effective agricultural pest management systems.

We express our gratitude to the many individual experts in pest management for different crops and regions of the country who contributed their wisdom to our analysis of alternatives in Chapter 3. We also thank the Pew Charitable Trusts, the Joyce Foundation and the W. Alton Jones Foundation for their support of our work.

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THE SKY IS FALLING!

"…Instead of homegrown fresh fruits and vegetables, expect them to be trucked in from other countries. Cherries, peaches and other fruits will likely come from South America. Our farmers will not be able to protect their crops economically enough to compete in the world market."
--Dr. Carl K. Winter, Editorial in Washington State Newspapers, June 1998

"For the vast majority of threatened pesticides, there are no alternatives in the development pipeline."
--Dean Kleckner, American Farm Bureau, April 1998

"I'm hearing that even in America we could be facing food shortages…."
--Representative Helen Chenoweth (R-ID), July 1998

A Campaign of Fear

Fear and loathing stalk the corridors of Washington. The ominous prospect that the Federal Government may regulate pesticide residues in the diet more effectively, to make foods safer for children to eat—as required by a law that Congress passed unanimously in 1996—has alarmist rhetoric flying around the Capitol like yellow jackets around a cider jug. Pesticide manufacturers, playing on farmers' legitimate anxieties about the potential loss of valuable insecticides, have spread rumors of a draconian government ban and have whipped up panic, hoping to stall implementation of the new law.

For more than a year, an uneasy truce held while all players in the pesticide debate waited to see how the U.S. Environmental Protection Agency (EPA) would implement the tough new law, called the Food Quality Protection Act (FQPA). But as the EPA began considering steps needed to attain the Act's health goals, it became clear that substantial changes in ways pesticides are used in food production will be required, and old, familiar battles erupted anew. As the outcry from the pesticide industry and growers has mounted, and their allies in Congress and the White House have urged EPA to slow down, public health and environmental advocates, in turn, have stepped up their own efforts to keep the promise of the FQPA alive.

At the heart of the anti-FQPA campaign is a rumor that EPA is planning an immediate ban of an entire class of insecticides, the organophosphates (OPs for short). More than 25 OP chemicals play an important role in farm production. They are registered for over 600 specific crop uses. A fear campaign built on the premise that EPA is about to ban the entire category, including about a dozen infrequently used OPs, has generated a drumbeat of propaganda: No alternatives exist for these insecticides; growers can't get along without them; EPA is out of control, about to impose irrational regulations that will jeopardize farmers' livelihoods and even the security of the food supply itself.

The message, in a nutshell, is that the sky is falling. In the familiar fable, it was Chicken Little who started that rumor, and soon had all other chickens in a tizzy. Let's listen in on the FQPA version of the tale:

> "…If FQPA implementation continues in this manner, sooner or later, virtually all pesticides and pesticide uses will be jeopardized. From wormy apples in agriculture, to cockroaches in the kitchen and crabgrass choking the lawn, Americans in every walk of life will miss the benefits of effective pest control."
> **--American Crop Protection Association, statement on ACPA web site, July 1998**
>
> "Without the OPs and carbamates, crop yields would drop significantly and certain crops simply could not be grown."
> **--Ibid., August 1998**
>
> "If, as has been rumored, EPA cancelled all OP registrations at once… an outbreak of the Mediterranean fruit fly in California or Florida could quickly devastate as much as 50 percent or more of each state's fresh produce business…. In apple-growing regions, growers would find their crops so infested by insect larvae that the fresh-apple market would be virtually destroyed."
> **--Ibid., August 1998**
>
> "In my mind, FQPA stands for 'farmers quit planting in America'."
> **--A farmer from Michigan, quoted on the ACPA web site, July 1998.**
>
> "FQPA could become Idaho agriculture's Waterloo, its Gettysburg, it's that serious…OPs are our antibiotics, carbamates our sulfa drugs."
> **--Pat Takasugi, Idaho Dept. of Agriculture, at EPA hearing in Boise, July 1998**
>
> "Unless FQPA is implemented fairly, small family operated farms will be forced out of business."
> **--A grower from Houston, TX, quoted on the ACPA web site, August 1998**

> "Maybe the EPA will do the right thing. Maybe it won't drive fruit and vegetable prices up, ensuring that children eat less of them. Maybe it won't kill asthmatic children by banning potent roach-killing sprays…."
> **--Michael Fumento, Op Ed piece in the Wall Street Journal, April 1998**
>
> "Act now! Or this may be the only pest control tool you'll ever use again!"
> **--Ad, sponsored by the ACPA and others; the ad pictures a flyswatter.**
>
> "Without [the OPs], farmers would face lower yields and more expensive alternatives to fight voracious insects. Some estimates indicate costs to agriculture could soar by $2 billion a year, which in turn would raise food costs."
> **--American Farm Bureau press release, April 1998**
>
> "The EPA has completely ignored the intent of this law and appears to be pushing their own extremist agenda…placing in jeopardy thousands of jobs in American agriculture."
> **--Press release, Office of Congressman Charles Stenholm (D-Texas), February 1998**
>
> "Our frustration grows each time we hear farmers describing the economic ruin they will face if EPA continues with their current implementation of FQPA…. Congress did not authorize EPA to implement a chemophobic agenda and jeopardize the availability of food to our children."
> **--Congressman Bob Goodlatte (R-VA) at an Agriculture Committee hearing in June, 1998**

This campaign has worked, as political fear campaigns often do. Publicity in farm districts provoked a stream of mail from alarmed constituents, and aroused pro-agriculture members of Congress. EPA could see which way the wind was blowing on Capitol Hill, and began tacking. Vice President Gore leapt into the fray in April, instructing the EPA and the Department of Agriculture together to make sure that all affected interests, especially those of agriculture, are taken into account as FQPA implementation proceeds.

In response to the Vice President's intervention, EPA and USDA set up a Tolerance Reassessment Advisory Committee (TRAC), a multi-stakeholder advisory group. Whether TRAC has brought EPA advice the agency would not have gotten in any case is unclear, but one thing is certain—the TRAC process has created numerous opportunities to slow FQPA implementation. Among other things, TRAC meetings have confronted EPA with arguments that, regardless of the public-health benefits of restricting the OPs and other high-risk pesticides, agriculture simply can't get along without them.

The Chicken Little fable we all heard as children ends tragically: A fox tells the panicked chickens the sky is indeed falling, invites them to take shelter in his den, and eats them. Perhaps this sad ending could have been averted if some wiser creature—let's say, an owl—had been there to say "Poppycock! The sky isn't falling! Stop this nonsense!" Even in Washington, in theory, a calm look at the facts and cool heads might restore sanity, once in a while.

To quell the anti-FQPA panic, we need an owl's-eye view of what the law requires EPA to do and how those goals could be achieved, and a wider awareness of the many alternatives readily available to growers to manage pests, if high-risk pesticide uses are indeed banned or severely restricted.

What the FQPA Requires EPA to Do

The source of all this anxiety is a law passed two years ago with almost no legislative wrangling. After years of stalemates in which neither industry interests nor environmental and public-health advocates had the votes to pass a pesticide regulatory reform bill over the other side's opposition, the combination of scientific consensus and election-year politics broke the log jam in 1996. Congress passed the FQPA that summer without a dissenting vote—the bill flew through both the House and the Senate in a matter of days, and President Clinton quickly signed it into law, beaming children at his side, radiating confidence that safer food would soon be at hand.

The FQPA aimed to solve myriad problems in pesticide regulation as carried out by the EPA. The so-called "Delaney Clause," a provision of various food safety laws that bans the knowing addition of any carcinogenic substance to foods, had in theory prohibited residues of most carcinogenic pesticides in processed foods. "In theory," because the ban had rarely been enforced, but a lawsuit filed by the Natural Resources Defense Council had, by 1996, put EPA on the brink of enforcing it. Passage of the FQPA avoided that, and replaced the "zero risk" approach of the Delaney Clause with a decision rule based on risk assessment, much preferred by the affected industries.

The FQPA establishes a single health-based standard for both processed and raw foods, and defines "safety" as "a reasonable certainty of no harm" to public health. This uniform standard, first proposed by a National Research Council study a decade earlier (NRC 1987), is a more "scientific" approach to risk management, and was welcomed by most parties.

But the FQPA also goes much farther than previous laws in specifying that foods should be "safe" for everyone—especially for infants, young children, and pregnant women. In doing so, the new law is Congress's response to a growing scientific consensus, best expressed in another National Research Council report, *Pesticides in the Diets of Infants and Children* (NRC 1993). That report identified several shortcomings in the way EPA has traditionally set legal limits for pesticides in foods (called tolerances) and concluded that existing tolerances do not provide an adequate safety margin for our most vulnerable citizens.

The NRC committee suggested that EPA apply an additional 10-fold margin of safety in setting acceptable levels of pesticide exposure, to better ensure safety for infants and children. It also recommended that pesticides that share the same mechanism of toxicity—such as the OP insecticides—be treated as a single hazard, since effects of multiple residues with the same toxic mechanism are likely to add up. It urged EPA, when setting tolerances, to account for non-dietary pesticide exposure, which occurs from drinking water and from pesticide use around the home, lawn and garden and in public buildings like schools, as well as for dietary exposure. Most importantly, the 1993 report urged that EPA's assessments of exposure to pesticides should reflect the unique, often higher exposures that infants and children receive from foods and other sources.

The FQPA incorporates those recommendations of the scientific community. It requires that EPA include, in most cases, an additional 10-fold margin of safety in setting safe exposure levels. Plus, the agency must account for all routes of exposure and the potentially greater susceptibility of infants and children. The law also spells out how EPA should deal with scientific uncertainty with respect to children's safety. Only when there is positive evidence that exposures are safe for infants and children can EPA elect not to include the additional 10-fold safety margin. If the agency has insufficient data to establish "reasonable certainty of no harm," the additional 10-fold safety margin is mandatory.

The FQPA also requires EPA to treat pesticides with a common toxic mechanism as a single hazard, and obligates EPA to consider dietary and non-dietary exposures in an integrated way.

The FQPA gives EPA some latitude to assess risks and set priorities, and like other pesticide laws, it sets deadlines for agency actions. By August of next year, for example, EPA must have completed its review of one-third of the existing 9,000 or so tolerances covering registered pesticide uses on food. The Act directs EPA to focus first on uses posing the greatest health risks, bringing those tolerances into compliance with the new safety standard of the Act. As EPA began wrestling with the challenge of setting priorities and choosing strategies for this "worst first" approach, some of the ideas it was considering early this year set off panic among the economic interests likely to be most affected.

Any assessment of risk priorities inevitably must focus on the OP and carbamate insecticides. Though in use for many years and comparatively low in cost, these two families include many of the most intensely toxic chemicals used on crops. They are widely used on foods that children eat a lot of, such as fruits and vegetables. All are toxic to the nervous system, and they all work by a common mechanism, inhibiting enzymes that play a vital role in the transmission of nerve signals. The risk of subtle adverse effects on the developing nervous system in children, which might show up later in life as learning difficulties or behavioral problems, is a central concern in setting safety standards for these insecticides. EPA made it clear shortly after the FQPA was passed that the OP and carbamate families would be among the first reassessed under the new safety standard.

Does that mean EPA must ban all OP and carbamate uses immediately? Of course not! Now, where's that wise old owl when we need her?

The Sky Is <u>Not</u> Falling!

Call it typecasting, but Consumers Union will play the role of the owl in this morality tale. We say, "Poppycock! The sky isn't falling!"

In place of rumor, we need facts. Two essential truths should help restore balance to this public debate:

(1) FQPA allows EPA to take **selective action**, using risk-based priorities to **eliminate high-risk pesticide uses**, without blanket bans. The goal of the FQPA is to reduce risk to within acceptable limits, not to eliminate pesticide use.

(2) There are **many viable alternatives** to high-risk OP and carbamate uses. If EPA were to ban or severely restrict those uses, farmers can rely on many safer methods for controlling pests.

The rest of this report spells out in detail the facts supporting those two conclusions. Chapter 2 shows where the risk is in kids' diets, and which insecticide uses contribute most to overall risk. We examined nine fruit and vegetable crops that kids eat in substantial quantities (apples, peaches, pears, grapes, oranges, green beans, peas, potatoes and tomatoes). For each crop, we used pesticide residue data collected by USDA and FDA to determine the fraction with residues of each OP and carbamate insecticide. Using the frequency of detection of residues and the relative toxicity of the individual pesticides—even within the same family, different chemicals differ widely in how toxic they are—we identified 40 "high-risk" uses, those that make the largest contributions to kids' dietary exposure and risk.

Those "Worst 40" uses, combined, seem very likely to account for the lion's share of risk kids are exposed to from OP and carbamate residues in foods. The Worst 40 uses are thus a logical focus for EPA's initial application of the new FQPA safety standard. By eliminating or tightly restricting just these 40 uses (out of over 600 permitted uses for the OPs, and about 100 for the carbamates), EPA could swiftly achieve a large reduction in risk.

In Chapter 3, we identify alternatives that can be used—in fact, *are being used now by many growers*—to manage the pest problems against which the Worst 40 OP and carbamate uses are weapons. Even the widely used OPs are typically applied to only small fractions of the acres of the treated crops in any given year. In 1996, according to USDA pesticide use data, 38 percent of vegetable acres were treated with one or more OPs; pests were managed without OP applications on 62 percent of the vegetable acreage. Figures for fruit acreage in 1995 are 44 percent treated with OPs, 56 percent not treated.

In short, more than half of fruit and vegetable acreage has been farmed without use of any OP insecticides in recent years. Instead, growers control insect pests with chemicals that pose lower risks of dietary exposure, with biopesticides, and with preventive practices that make up the systematic approach called Integrated Pest Management, or IPM for short (see Benbrook et al., 1996 for a detailed discussion of IPM). Because of declining efficacy, to protect farm workers' safety and in response to consumer demand for safer foods, use of the OPs has been declining for a decade or so in most crops. FQPA implementation will not turn agricultural pest control upside down; it will merely accelerate trends already being driven by other forces. And EPA's effort to reduce pesticide risks to children will not disrupt the food supply.

While good alternative pest control choices exist for most of the Worst 40 OP and carbamate uses, EPA can't simply wave a magic wand—whoops, wrong fairy tale—and make these high-risk pesticide uses disappear. It will require intensive collaboration involving the agency, the USDA, and affected parties to ensure that growers have the information—and confidence—needed to apply available and emerging alternatives.

In a few cases, viable alternatives may not be widely accessible or adopted yet, and EPA may need to restrict, rather than ban, certain highly valuable insecticide uses. Typical restrictions should aim to prevent leaving any detectable residues in foods—by requiring a longer interval between application and harvest, for example. EPA may also need to provide for "emergency" use of restricted chemicals, where crop loss is threatened. Appropriate safeguards need to be put in place to make sure emergency-use exemptions are invoked only if no other option is available, and not abused to keep otherwise banned chemicals in wide use.

America <u>can</u> have both a safer food supply and productive, increasingly sustainable agriculture. The goals are not mutually exclusive; they can even be mutually supportive. It is time to cut through the smog of politically inspired fear, get all the relevant facts on the table, and start making smart regulatory decisions that deliver on the promises of the FQPA.

Chapter 2

WHERE THE RISK IS

The Worst 40 Insecticide-Food Combinations in Children's Diets

The Risk Cup Overfloweth

The FQPA commands the EPA to reduce risks from pesticides in the diet to levels that have a "reasonable certainty of no harm" to public health, and to ensure that children's health is protected.

How much reduction in exposure will be required to meet that goal? EPA can't say yet. Especially for chemicals with a common toxic mechanism like the OP and carbamate insecticides, EPA must first determine what a safe overall exposure to members of the class is. Then the agency must determine how much current risk exists from cumulative exposure to all members of the category through dietary residues and non-food exposures. The degree to which current cumulative risk exceeds the safe exposure is the amount of risk reduction needed.

EPA has coined the term "the risk cup" to describe the acceptable risk level; it's the sum of exposures that, together, don't exceed a maximum safe daily intake for kids. Imagine a container, or cup, with a fixed capacity, and think of each individual pesticide use as creating a risk of some size that fills part of the cup. The risk cup for OP insecticides, for instance, may allow a good number of crop-specific uses, as long as aggregate exposure and risk from all those uses (and from other permitted non-dietary exposure to OPs) does not exceed the maximum safe level, i.e., doesn't make the risk cup overflow.

There's a lot of uncertainty so far over just how big the risk cup (or cups) for the OPs and carbamates will be. But based on the work done by the NRC's Committee on Pesticides in the Diets of Infants and Children (NRC 1993), and earlier this year by the Environmental Working Group (EWG 1998), dietary exposure currently appears to exceed a safe level by a wide margin. In a recent presentation to its Tolerance Reassessment Advisory Committee, EPA reported the results of preliminary analyses suggesting that about 20 OP insecticides exceed safe exposure levels on their own—without considering their common toxic mechanism.

Does that mean that all OP and carbamate uses must be eliminated, or that every tolerance for use of these insecticides on foods has to be revoked or drastically reduced? No, not necessarily. Some uses pose far greater risks than others. For example, insecticides applied early in the growing season often leave no detectable residues on the harvested crop, and can reasonably be assumed to pose significantly smaller risks than applications later in the season. Other uses, on crops that kids seldom eat, also contribute less to risk, at least for infants and children. On the other hand, applications close to harvest time on foods that are prominent in children's diets are most likely to contribute heavily to overall dietary exposure and risk.

EPA's challenge is to manage the aggregate risk by eliminating pesticide uses that create the biggest risks, making room in the risk cup for other lower-risk uses of economically valuable chemicals. The FQPA in fact requires EPA to prioritize among risks and to regulate the "worst first."

High-Risk Insecticide Uses

EPA has already made it clear that, collectively, the OPs and carbamates fall into the high-risk category. But different uses pose different risks. How can big risks be sorted out from little risks in this category, to determine what uses fit within the risk cup?

Our analysis identifies high-risk OP and carbamate uses. We have focused on the central mandate of FQPA—protecting children's health—and defined high-risk based on three factors: The role of specific foods in children's diets; the occurrence of residues of specific OP and carbamate insecticides on or in foods kids eat a lot of; and the relative toxicity of the residues. Insecticide uses we consider "high-risk" are those that frequently leave residues of comparatively toxic members of these chemical families in foods kids consume a lot of.

We have identified 40 specific crop-chemical uses that are "high risk" by our criteria; they're listed in Table 2.1. These 40 uses are a small fraction of

Table 2.1. The Worst 40: High-Risk Insecticide-Crop Uses

Fruits: Crops/Foods	Fruits: Insecticides	Vegetables: Crops/Foods	Vegetables: Insecticides
Apples	Azinphos-methyl Chlorpyrifos Methyl Parathion Dimethoate Carbaryl Oxamyl	**Green Beans**	Methyl Parathion Methamidophos Dimethoate Acephate Carbaryl
Pears	Azinphos-methyl Methyl Parathion Phosmet Carbaryl Oxamyl	**Peas**	Dimethoate Acephate
Peaches	Azinphos-methyl Chlorpyrifos Diazinon Methyl Parathion Phosmet Formetanate HCL Aldicarb Carbaryl	**Potatoes**	Methamidophos Aldicarb
Grapes	Azinphos-methyl Chlorpyrifos Formetanate HCL Dimethoate Methomyl Carbaryl	**Tomatoes**	Azinphos-methyl Chlorpyrifos Methamidophos
Oranges	Methidathion Chlorpyrifos Carbaryl		

the estimated 300 current food-production uses of OPs and carbamates that entail applications to more than 1 percent of national crop acreage (and an even smaller fraction of the estimated 700 registered, or legally permitted, uses). But, collectively, they account for a disproportionately large share of total risk associated with insecticide use on food crops. These "Worst 40" uses are clear top priorities for EPA's risk management efforts under FQPA.

As Table 2.1 shows, the 40 specific uses involve 14 insecticides used in various combinations on nine food crops. The rest of this chapter explains how we identified them as the "Worst 40."

Identifying Foods Consumed in Disproportionate Amounts By Infants and Children

As stated in *Pesticides in the Diets of Infants and Children* (NRC 1993), "Children…consume more calories of food per unit of body weight than do adults. At the same time, infants and children consume far fewer types of food than do adults." Differences in dietary exposure attributable to these two combined factors are among the most important reasons children face greater health risks from pesticides than adults do.

We began our screening for high-risk insecticide uses by looking at food intake data, to determine which foods kids eat in significant quantities. The 1993 NRC report identifies 23 foods or food groups that each make up more than 1 percent of the diets of children at some point from infancy through age 12, based on a national food consumption survey conducted in 1977-1978. (Though dated, these survey data are the most comprehensive available.) Table 2.2 lists these 23 foods, and shows how much each contributes to the diet for children of different ages.

A more recent survey (USDA 1996) focused on food intake by children showed largely the same food consumption patterns, but noted some changing trends. The survey found that:

- Kids are consuming more beverages, grain-based snacks and combination foods like pizza, and eating away from home more.
- Kids' milk and fat consumption is declining.
- Consumption of conveniently packaged drinks based on apple, grape and mixed fruit juices is rising markedly. Soft drinks account for the rest of the increase in beverage consumption.

Table 2.2. Foods and Crops That Account for More Than 1 Percent of the Diet of Infants and Children					
Food	**Nursing Infants**	**Non-nursing Infants**	**One to Six Year Olds**	**Age Seven to Twelve**	**Age 13 to 19 Years**
	Percent of Average Diet by Age Group				
Milk and Dairy	36%	58%	44%	42%	42%
Fruits					
Apples	15.5%	7.6%	4.1%	2.1%	1.6%
Peaches	4.1%	2.3%	<1%	<1%	<1%
Pears	4.3%	1.9%	<1%	<1%	<1%
Orange Juice	4.5%	3.2%	5.7%	4.6%	4.2%
Bananas	2.7%	1.1%	<1%	<1%	<1%
Total Fruits	31.1%	16.1%	11.3%	8.2%	7.3%
Grain Based Products					
Wheat Flour	<1%	1.0%	4.6%	5.8%	6.1%
Oats	1.2%	<1%	<1%	<1%	<1%
Milled Rice	1.8%	1.5%	<1%	<1%	<1%
Total Grains	3.5%	3.0%	5.60%	6.8%	7.1%
Vegetables					
Tomatoes	<1%	<1%	1.4%	1.7%	2.1%
Carrots	3.3%	1.6%	<1%	<1%	<1%
Peas	1.3%	<1%	<1%	<1%	<1%
Beans	1.3%	<1%	<1%	<1%	<1%
Potato	<1%	<1%	3.9%	4.6%	5.3%
Sweet Corn	<1%	<1%	<1%	1.1%	1.1%
Total Vegetables	7.4%	4.1%	7.3%	8.9%	10.0%
Other					
Beef (lean plus fat)	3.0%	1.5%	4.6%	5.7%	7.1%
Soybean Oil	1.1%	1.5%	1.0%	1.2%	1.4%
Coconut Oil	<1%	1.4%	<1%	<1%	<1%
Cane Sugar	<1%	<1%	3.1%	3.4%	3.7%
Eggs	<1%	<1%	1.4%	1.4%	1.6%
Beet Sugar	<1%	<1%	1.4%	1.5%	1.7%
Pork	<1%	<1%	1.2%	1.3%	1.8%
Chicken	<1%	<1%	1.4%	1.4%	1.6%
Total Other	7.1%	6.9%	14.6%	16.4%	19.4%
Note: All foods @ <1% of consumption assumed to account for 0.5% in estimating totals.					
Source: Table 5-6, *Pesticides in the Diets of Infants and Children* (NRC 1993).					

A few points shown in Table 2.2 are worth highlighting. Food consumption patterns change dramatically as children pass through infancy and the first few years of life, and continue to change as they mature into adults.

Milk and dairy products are the single biggest dietary component for infants and children. Next to milk, Table 2.2 shows that orange juice makes up the greatest percentage of the diet for children ages one to six years. Apples, apple juice, peaches and pears are consumed by children under age one in amounts that are five to 15 times the national average intake per unit of body weight, and non-citrus juices now account for 6 percent of total daily food intake of three to five year-olds—about three times average intake (USDA 1996). Kids older than 5 years switch from apple to citrus as the dominant juices in their diets, and non-milk beverages displace milk as kids reach their teens. As children grow older, vegetable consumption increases, led by potato and tomato-based products, while fruit intake declines.

Our analysis of the foods most likely to contribute to dietary insecticide exposure in children narrowed the focus to nine high-intake foods. They include one not listed in Table 2.2—grapes—and eight others that do appear in the table, all fruits and vegetables. The nine foods are: apples, pears, peaches, grapes and oranges; peas, green beans, potatoes and tomatoes.

In selecting these nine foods, we relied on two additional kinds of data: The frequency of detection of insecticide residues in the foods, and the relative toxicity of residues commonly detected in each food.

Grapes made our list, although they accounted for less than 1 percent of children's diets in the 1977-78 food survey, because their consumption in fresh, processed and juice forms has grown rapidly since then. An analysis by the Environmental Working Group published earlier this year showed that grape-based foods contribute significantly to excessive OP exposure in children's diets (EWG 1998).

Foods in Table 2.2 that are <u>not</u> among our chosen nine high-risk foods are typically less likely to contain insecticide residues than foods we selected. Carrots generally have very rare, low residues of OPs and carbamates; edible portions of sweet corn and bananas are also comparatively "clean," although more residues are found on inedible outer husks. OP and carbamate residues are almost completely absent from milk and dairy products, meats, vegetable oils, and sweeteners.

We also excluded all grain-based products, for somewhat different reasons. Most growing-season insecticide uses on these crops leave no detectable residues when foods are consumed. On the other hand, post-harvest insect control, during storage, transportation and processing of grains, often does leave residues, which contribute significantly to children's overall dietary exposure (EWG 1998). However, our focus in this report is on insecticide use in farm production and on safer alternative pest management choices that growers can use.

Identifying the Most Toxic Insecticides Found in Foods

Pesticides are not all equally toxic, and the degree of risk posed by dietary insecticide residues depends on the toxicity of the individual insecticides, as well as on the frequency of occurrence and level of residues present. The second step in our screening for high-risk insecticide uses was to look at the comparative toxicity of different OP and carbamate compounds commonly found in foods.

Pesticide toxicity is measured in many ways. At least two kinds of adverse effects are considered: ***acute toxicity***, in which effects on one or more body systems are detected immediately following exposure; and ***chronic toxicity***, in which effects occur only after longer-term, lower-level exposure, or long after an acute exposure. Typically, toxicity is tested in a variety of animal experiments, and data from human (usually, occupational) exposure are also relied on when available.

An index of how toxic an insecticide is, widely used by risk assessors and regulators, is the ***reference dose***, or RfD for short. The RfD is an exposure level, expressed in milligrams of chemical per kilogram of body weight of the exposed individuals per day, estimated to pose no appreciable risk of adverse effect in people. Most chemicals have an RfD for chronic effects, and some may have one for acute effects, as well.

Toxicologists calculate an RfD by first determining the lowest level of exposure to a chemical that produced an adverse effect in a well-designed animal study. The next exposure level below that—the highest dose that produced no observable, statistically significant adverse effect in the group of animals exposed to it—is called the No Observable Adverse Effect Level, or NOAEL. The NOAEL is typically divided by a "safety factor"—ranging from 100 to 1,000 depending on the extent and quality of available data—to produce the RfD, the estimated safe daily dose for humans, including of course vulnerable population groups like children.

RfDs may be based on any of a wide array of toxic effects; ordinarily, the adverse effect that occurs at the lowest level of exposure is deemed most critical, and is the basis for the RfD. For most insecticides, especially OPs and carbamates that share a common mechanism of toxicity, effects on the nervous system are the uniform basis for RfDs. This allows straightforward comparisons of relative toxicity for members of these families.

Table 2.3 displays chronic RfDs for the OP and carbamate insecticides. These RfDs are based on the EPA's risk assessments, and are the agency's current official estimates of the "safe" dose for each chemical listed.

Since an RfD is derived from the amount of a chemical required to produce an adverse effect, the smaller the RfD, the less of a substance needed to have toxic effects, and the more hazardous the chemical. Among the OPs shown in Table 2.3, there is a 2,000-fold difference in chronic toxicity between methyl parathion and malathion. Among carbamates, oxamyl and aldicarb are about 70 and 14 times as toxic, respectively, as carbaryl, based on comparative chronic RfDs for the three insecticides. Comparing across the two groups, methyl parathion is 700 times as toxic as carbaryl.

The most toxic insecticides are very toxic indeed. The cumulative toxicity of the OPs found in apples and in peaches is such that a child who eats three-fourths of an apple, or a whole peach, has roughly a one-in-four chance of exceeding the RfD (i.e., the safe daily intake) for OPs, just from eating that one food item (EWG 1998).

Some of the most toxic OP and carbamate insecticides are severely restricted by EPA and may not legally be used on most crops. They are rarely found in the foods they can be applied to. Other members of these two chemical families, such as acephate, azinphos-methyl or carbaryl, are much less toxic but are much more widely used, and consequently may contribute significantly to the overall risk from insecticide residues in foods eaten widely by children.

Such wide differences in toxicity within a chemical family make it clear that some insecticides of each type are far riskier, and some are far less risky, than others.

Table 2.3. Comparative Chronic Toxicity of the Organophosphate and Carbamate Insecticides

Insecticide	OPP/EPA Chronic Reference Dose (mg/kg body weight)
Organophosphates	
Methyl Parathion	0.00002
Profenofos	0.00005
Terbufos	0.00005
Pirimiphos methyl	0.00008
Dicrotophos	0.0001
Ethoprop	0.0001
Fenamiphos	0.0001
Dichlorvos	0.00017
Chlorpyrifos	0.0003
Disulfoton	0.0003
Ethyl parathion	0.00033
Dimethoate	0.0005
Ethion	0.0005
Oxydemeton-methyl	0.0005
Phorate	0.0005
Chlorethoxyfos	0.0006
Diazinon	0.0007
Methamidophos	0.001
Acephate	0.0012
Azinphos-methyl	0.0015
Methidathion	0.0015
Fonofos	0.002
Naled	0.002
Lower Risk OPs	
Phosmet	0.003
Sulprofos	0.003
Chlorpyrifos-methyl	0.01
Malathion	0.04
Carbamates	
Oxamyl	0.0002
Aldicarb	0.001
Formetanate HCL	0.002
Carbofuran	0.005
Lower Risk Carbamates	
Methomyl	0.008
Carbaryl	0.014
Thiodicarb	0.03
Fenoxycarb	0.08

EPA will need to draw such distinctions in setting regulatory priorities. In Table 2.3, we have indicated where we think reasonable lines might be drawn between high-risk and lower-risk members of these two insecticide groups.

Highest-Risk Food/Insecticide Combinations

How important a particular food's contribution is to children's overall risk from insecticide exposure depends on which insecticides are used on the crop, and on the extent to which residues remain in the food as eaten. As we explained earlier, we relied on qualitative comparisons of residue prevalence to narrow the list of high-intake foods down to nine, and we collected data on the relative toxicity of all the OP and carbamate insecticides frequently found on foods. Then we took a closer look at residues in the nine foods, to affirm that they belong in the "high-risk" category and to identify the specific insecticide uses that seem most likely to drive children's dietary exposure and risk.

The data we examined come from two major Federal Government pesticide residue testing programs. The U.S. Department of Agriculture (USDA) tests foods for pesticide residues, with emphasis on monitoring foods eaten in quantity by children. The USDA Pesticide Data Program (PDP) tests foods "as eaten"—washed, peeled, and for processed foods, cooked.

But the PDP tests only some 14 high-consumption foods. To get a broader picture of residues in foods, we supplemented our analysis of PDP data by examining results from the U.S. Food and Drug Administration's Pesticide Surveillance and Monitoring Program. The FDA carries out comprehensive annual testing to enforce tolerances for residues, collecting samples just after the foods leave the farm. The samples are tested "as is," without washing, peeling or cooking. These methods find residues somewhat more often, and at higher levels, than the PDP testing finds. Still, the FDA data are among the best available to assess residue levels in foods not tested by the PDP.

Table 2.4 presents an overview of OP and carbamate residues in our nine high-consumption children's foods. The table shows the percent of samples of each food item tested by USDA or FDA that were positive for each listed insecticide. Eleven OPs and five carbamates were detected frequently in the nine foods, and are listed. Other members of these insecticide families were found so infrequently and at such low levels that they contribute modestly at most to dietary exposure, and we have excluded them from this analysis.

Table 2.4. Frequency of Detection of Organophosphate and Carbamate Insecticide Residues in High-Consumption Children's Foods

Percent of Samples Positive for Residue ("Worst 40" in **bold** type)

Fruits	Apples (Fresh / Juice)	Pears (Fresh / Juice)	Peaches	Grapes	Oranges
Organophosphates					
Acephate	/ 0.6	2.0 /	0.8		
Azinphos-methyl	**54.5** / 5.1	**28.0** / 100	**33.3**	**3.0**	0.2
Chlorpyrifos	**26.4** /		**17.0**	**13.7**	**12.0**
Diazinon	0.2 /		**3.7**	1.9	
Dimethoate	**2.8** / 9.0			**16.6**	0.4
Malathion	0.5 / 0.6		0.8		0.8
Methamidophos	0.5 / 1.1	2.0 /	0.3		
Methidathion					**6.4**
Methyl Parathion	**5.7** /	**10.0** /	**25.3**		
Phorate					
Phosmet	3.6 / 2.6	**13.0** /	**27.5**	2.7	
Carbamates					
Aldicarb			**7.1**		0.4
Carbaryl	**12.3** / 32.2	**29.0** / 100	**16.0**	**6.5**	**11.8**
Formetanate HCl	1.5 /		**4.3**	**3.4**	
Methomyl	2.1 /		1.2	**7.4**	
Oxamyl	**3.4** /	**6.3** /			

Vegetables	Green Beans	Peas	Potatoes	Tomatoes
Organophosphates				
Acephate	**33.5**	**3.7**		0.6
Azinphos-methyl				**4.6**
Chlorpyrifos		0.3		**9.8**
Diazinon	0.8	0.6		
Dimethoate	**2.8**	**13.8**		0.4
Malathion				0.4
Methamidophos	**32.2**	0.3	**2.0**	**37.4**
Methidathion				
Methyl Parathion	**3.4**	0.8		0.4
Phorate			1.8	
Phosmet				0.6
Carbamates				
Aldicarb	0.2		**19.0**	
Carbaryl	**11.9**	2.0		1.1
Formetanate HCl				
Methomyl	0.9			
Oxamyl				1.1

Data for apples and pears are split into fresh and juice food forms because the residue data are reported that way, but we consider such paired subsets to be single food-insecticide combinations, since both represent the same crop. A blank cell in the table means the insecticide in that row was not detected in the food at the top of the column. Seventy food-insecticide combinations fall into this non-detected category; residues were found in 74 cases.

To determine which of those 74 positive combinations are "high-risk" food-insecticide uses, we applied two criteria: frequency of residue detection, and relative toxicity of the individual insecticides. The "Worst 40" uses are in bold type in Table 2.4. Here are the criteria we used to select them:

- For most OP and carbamate insecticides, those uses that leave residues in 2 percent or more of PDP samples, or in 4 percent or more of FDA surveillance samples, are classed as "high-risk" combinations.

- For the "lower-risk" OPs phosmet and malathion, and for the carbamates carbaryl and methomyl, crop uses that leave residues in more than 5 percent of the tested samples are classed as "high-risk" combinations.

Among the Worst 40 insecticide-food combinations (excluding the juices), 21 have detection frequencies of 10 percent or higher and 10 combinations exceed 25 percent frequency. In the worst case, children who eat apples are likely to be exposed to azinphos-methyl 54.5 percent of the time.

As Tables 2.1 and 2.4 show, "high-risk" uses are concentrated in five foods: peaches (8), apples (6), grapes (6), green beans (5) and pears (5) account for 30 of the Worst 40 insecticide-food combinations. The most worrisome OPs are azinphos-methyl and chlorpyrifos, each in five of the nine foods, and methyl parathion, in four. Among carbamates, aldicarb is the most serious concern because of its high acute toxicity, its presence in potatoes, a major food, and recent increases in the percent of acres treated. Carbaryl is found frequently in six of the nine foods, but is far less toxic than aldicarb.

For a more detailed and elegant analysis of pesticide residues in children's diets, and one that also supports our selection of high-risk insecticide-food combinations, we refer readers to the Environmental Working Group's 1998 report, "Overexposed: Organophosphate Insecticides in Children's Food" (EWG 1998). We also invite readers to visit our project web site for our own more detailed analysis (http://www.ecologic-ipm.com).

Chapter 3

MULTIPLE CHOICE

Alternatives to the Worst 40 Insecticide Uses

High-Risk Uses Are Already Declining

Suppose EPA took our advice and swiftly eliminated the Worst 40 insecticide uses on high consumption children's foods, identified in Chapter 2. Would agriculture collapse? Would consumers find wormy apples in stores, as the cost of protecting kids from insecticide residues in their foods? No, not at all.

The fact is that most growers of the nine crops on which the Worst 40 insecticide uses occur *already* get by without using these high-risk chemicals, or are *already* using them in ways that tend to minimize the risk of dietary exposure. Table 2.4 shows that about half of the Worst 40 uses leave residues in 10 percent or less of tested samples of the crop, and only one of the 40 uses, azinphos-methyl on apples, produces residues in more than half the samples the government tests.

Why? On-farm pest management is a complex art, and control of particular insect pests rarely depends on single chemicals. Growers have a veritable arsenal of both chemical and non-chemical weapons to use against insects that attack their crops. While the high-risk OP and carbamate insecticides are considered "products of choice" by many growers, because they kill so many different pests and are fast-acting and low in cost, their use on many crops has been declining for a decade or more, for several reasons.

One of the most prominent reasons farmers turn to new methods of insect control is resistance, the well-documented development of "immunity" to specific insecticides by the target pests. Many pest populations are resistant to many of the carbamates and OPs. Farmers also may choose lower-risk alternatives in the interest of worker safety, and to a degree, in response to consumer demands for safer foods. And the market for pest-control products continues to offer new, safer options.

Overview of Alternatives

Growers can draw on five basic categories of insect pest-management "weapons:"

1) High Risk OP and Carbamate Uses – All uses of high-risk OPs and carbamates on these nine crops, including the worst 40 identified in Chapter 2.

2) Conventional Alternatives – Insecticides currently registered and used in recent years to manage the same insect pests that are targets of the "Worst 40" uses. These include the lower-risk OPs and carbamates shown in Table 2.3, as well as several synthetic pyrethroid insecticides, which are generally much less toxic to mammals than the high-risk OPs and carbamates.

3) Reduced-Risk Alternatives – Insecticides that typically pose significantly lower risks per acre treated, because of low application rates and/or low-toxicity. Most are quite selective (they affect just the target pest and closely related species and so have fewer side effects than the synthetic pyrethroids). This category includes insect growth regulators (IGRs) like tebufenozide, fenoxycarb and pyripoxyfen; nicotinoid insecticides such as imidacloprid and thiamethoxam; new aphicides pymetrozine and pirimicarb; and the miticides pyridaben and abamectin.

4) BioBased Alternatives -- Biologically-based insecticides and natural control products like horticultural oils, sulfur and pyrethrins. These alternatives include commercial preparations of naturally occurring bacterial and viral insecticides like *Bacillus thuringiensis* (*Bt*), Nuclear Polyhedrosis Viruses, and *Beauveria bassiana*; pheromone products used in mating disruption and pheromone-based "Attract and Kill" feeding stations and traps; and natural biopesticides such as azadirachtin (neem) and the concentrated fermentation product spinosad, a very promising new bioinsecticide.

5) BioIPM Practices – Tactics suitable for incorporation in biointensive Integrated Pest Management systems that rely predominantly on preventing pest problems by manipulating relationships between plants, beneficial organisms and pests. BioIPM Practices include planting resistant varieties, cultural practices to avoid introduction of pathogens or eliminate habitat needed by pests, crop rotation, soil fertility and irrigation management, building and maintaining populations of natural enemies of insect pests (known as beneficials), and measures to block or disrupt reproduction.

We examined alternatives for the Worst 40 insecticide uses on the nine crops we surveyed and identified 10 to 15 alternatives that farmers can choose instead of using the high-risk OPs and carbamates on each crop. In a typical case, the choices include four or five Conventional Alternatives, two to four Reduced Risk Alternatives, three or four BioBased Alternatives, and two to four BioIPM Practices. Control of the pest problems that result in the Worst 40 uses truly presents growers with a "multiple choice" pest-management challenge.

Some important caveats need to be stated. Pest management is more complicated than simply substituting one chemical, or one technique, for another. Some of the alternative insecticides pose non-health risks that in some circumstances can be significant. For example, synthetic pyrethroids harm a wide range of beneficials and can trigger severe outbreaks of mites and other secondary pests. Switching to a new strategy to manage a chronic crop pest often requires learning new techniques of timing and application methods to minimize impacts on beneficials. It requires added attention to weather, growing conditions, the status of pest populations and their natural enemies. The transition may take some time. Sometimes, growers who elect not to use a high-risk OP or carbamate may need to use several alternatives in combination, to achieve equally effective pest control.

New reduced-risk insecticides can be effective substitutes for certain high-risk applications in some crops, especially when they are used in conjunction with a BioBased product like *Bt* or mating disruption. Imidacloprid (Admire) has proven very effective in controlling aphids and the Colorado potato beetle on potato farms, and has markedly lessened reliance on several OPs and carbamates. It has also made a big difference in tomato production. The biopesticide spinosad is proving effective in controlling a number of insect species, and in some cases is a one-for-one substitute for application of an OP or carbamate.

In some cases, adoption of alternatives may require more applications of insecticides than using the high-risk chemicals did. Sometimes alternative systems will include lower-risk OPs and carbamates that we identify in some crops as a high-risk use because of the prevalence of residues. But while pounds of insecticides applied may go up, risk will go down markedly, because of the vastly lower toxicity of the alternatives that replace the hazardous OPs and carbamates. Similarly, while many of the alternatives are cost-competitive with the high-risk insecticide uses, some are more expensive. Replacement of the Worst 40 uses could in some cases lead to slightly higher short-term costs for pest management. We believe, however, that any effect on consumer prices would be minimal, and that consumers would willingly absorb such slight increases in food costs in return for the accompanying reduction in risks from insecticide residues.

In the sections that follow, we examine the choices available for each of the nine crops and Worst 40 uses. In each major producing state in which one of the nine are grown, we first did a pesticide use profile, based on reports from the National Agricultural Statistical Service (NASS) of USDA. We then consulted with a wide array of pest management experts knowledgeable about that crop, and asked them about pest management methods now in use, including some that might be used more widely if EPA were to restrict the Worst 40 uses that apply to the crop in question. Our contacts included agricultural extension staff, academic and government scientists, private pest-management consultants and others. Appendix A provides notes on sources of data that we gathered on each of the nine crops.

We found many good alternative pest-management choices, as we'll detail below. We also found some surprising good news: For six of our Worst 40 insecticide-food combinations, the most recent NASS pesticide use reports show no use of that insecticide on that crop. (In the NASS surveys, if a chemical is used on less than 1 percent of harvested acres, it is reported as "no use.") In other words, U.S. growers *already have essentially eliminated six of the Worst 40 uses*. The six uses are: aldicarb on peaches; oxamyl on pears; azinphos-methyl and formetanate hydrochloride on grapes; acephate on peas; and chlorpyrifos on tomatoes.

Recall that our criteria for choosing the Worst 40 included frequency of detection of residues in foods that kids eat in quantity. How can there be residues, if growers are not using the chemical? A likely answer is that residues from some of these six uses occur in imported food samples, which make up a significant share of the market for some of our nine crops. That means if EPA sets much lower tolerances for these six uses, it will reduce risk for American consumers without imposing new costs on at least the vast majority of American farmers.

Here, now, are the crop-by-crop case studies. For each crop, we summarize the crop-specific insecticide uses that are on our Worst 40 list, and briefly describe the national production profile for the crop, the crop's current pesticide-use profile and major insect pest problems. (More detailed discussions of each crop will be available soon on our project web site.) We then summarize alternatives available to growers for managing the pests that require the crop's high-risk insecticide uses. Summaries are presented in tables. The Worst 40 uses, and the pest problems that they are used to control, are highlighted in bold type in the tables.

APPLES

"Worst 40" Insecticide uses: azinphos-methyl
chlorpyrifos
methyl parathion
dimethoate
carbaryl
oxamyl

Production Profile: Five states account for 70 percent of the 460,000 apple-bearing acres in 1995: Washington, California, New York, Michigan and Pennsylvania (Noncitrus Fruits and Nuts, NASS 1998).

Pesticide Use Profile: Large differences in pesticide use exist in different apple-producing regions because of different pest and climatic conditions. Overall, 94 percent of apple acreage surveyed by USDA in 1995 were treated with an OP, an average of 5.9 times per acre. Seventy-five percent of the acres were treated with a carbamate, an average of 3.0 times. Azinphos-methyl appears to be the most widely applied insecticides in these families in the five major states.

The average apple acre in California was treated with OPs or carbamates only four times, while the average Pennsylvania acre was treated 12.5 times. The difference reflects, in part, the alternate row spraying technique favored on Pennsylvania apple farms (alternate rows are skipped in each application and lower rates are used per acre, but orchards are sprayed more often). In terms of pounds applied, Washington and Michigan growers applied the most OPs and carbamates, roughly 7 pounds per acre, while Pennsylvania growers applied only 3.9 pounds per acre (Agricultural Chemical Usage: 1995 Fruits Summary, NASS 1996).

***Pest Profile*:** Pest problems driving OP and carbamate use on apples differ by region. In the West, codling moth, leafrollers and leafminers, aphids, and San Jose scale are the most serious apple pests. In the East, the leafroller, tufted apple budmoth, European red mite, plum curculio, apple maggot and oriental fruit moth are more likely to cause serious damage. Some insects migrate into orchards as adults and can cause serious damage. Species posing periodic problems include lygus, stinkbugs, and in the Northwest, the recently resurgent cutworm *Lacanobia subjuncta*.

***Alternatives to High-Risk OPs and Carbamates*:** For nearly all apple insects driving high-risk OP and carbamate use in the top five apple producing states, we found ample, markedly safer alternatives. The one exception is plum curculio management in some New England states and Michigan. On most farms in these states, the only viable alternative to azinphos-methyl in recent years has been the lower-risk OP phosmet, use of which reduces risk but less significantly than desirable.

Apple insect pest management alternatives are listed by category in Table 3.1, below. Since Apples is the first of our nine case studies, we will discuss some identified alternatives in detail here. As we move through the case studies, readers will note that many of the same pests attack more than one of our nine crops, and the same insecticides are used to combat them, injecting an element of repetition into the alternative profiles for many of the Worst 40 uses. We will present these details but once; with only slight modifications, the descriptions of alternatives to, say, azinphos-methyl use for codling moth control, would be essentially the same for pears as they are for apples. In later cases, the tables will largely suffice.

As Table 3.1 shows, the Conventional Alternatives available to apple growers to help manage each of the target pests are likely to include some lower-risk OPs and carbamates, as well as one or two synthetic pyrethroids. But future use of two chlorinated hydrocarbon insecticides—methoxychlor and endosulfan—is in doubt, since both are endocrine disruptors, and the environmental persistence of these insecticides enhances the risk that they will leave residues in foods.

The IGR tebufenozide (Confirm), introduced to wide commercial use in 1998, is a key new tool to augment other BioBased alternatives. If used in conjunction with phosmet at a lower application rate as an alternative to azinphos-methyl, this IGR offers a lower-risk approach for plum curculio control; it can provide an adequate level of control with reduced risk.

Plum curculio and another eastern insect pest, apple maggot, are two problems for which alternatives are thinnest. Some growers are experimenting in New England with novel trapping methods and field-edge systems in managing apple maggots. Research is underway at several Land Grant Universities to find better alternatives to control the plum curculio. This is why we foresee the need for continued use of several lower-risk OP and carbamates in eastern apple IPM programs.

Table 3.1. Alternatives to High-Risk OPs and Carbamates Used in Apple Production

	High-Risk OP/Carbamate Uses	Conventional Alternatives	Reduced Risk Alternatives	BioBased Alternatives	BioIPM Practices
APPLE PESTS					
Codling Moth	**Azinphos-methyl** **Methyl Parathion** **Carbaryl**	Esfenvalerate Phosmet Malathion Methomyl	Fenoxycarb+ Tebufenozide+ Other IGRs DPX-MP062+	Spinosad Codling Moth Pheromone *Bt* Narrow range Oils	Mating Disruption Release of *Trichogramma platneri*
Leafrollers/ Leafminers	**Chlorpyrifos** **Methyl Parathion** **Dimethoate** Carbaryl Oxamyl	Esfenvalerate Permethrin Phosmet Methomyl Endosulfan* Fenbutatin-oxide Malathion	Abamectin Imidacloprid Tebufenozide+ Fenoxycarb+ Pyriproxyfen+ Buprofezin+	Spinosad *Bt* Sprayable pheromones Narrow range Oils	Mating Disruption+ Culture of non-pest leafroller species to build natural enemies
Plum Curculio (Eastern States)	**Methyl Parathion** **Azinphos-methyl**	Esfenvalerate Permethrin Phosmet Malathion Methoxychlor*	**?**	**?**	**?**
Apple Maggot (Eastern States)	**Chlorpyrifos** **Methyl Parathion** **Carbaryl** Diazinon Formetanate HCL	Phosmet Esfenvalerate Methoxychlor*	Imidacloprid IGRs+	Attract and Kill Systems	Trap crops and border sprays+
Oriental Fruit Moth (OFM)	**Chlorpyrifos** **Methyl Parathion**	Esfenvalerate Phosmet	DPX-MP062+	*Bt* OFM Pheromone	Mating Disruption Braconid wasps++
Mites	**Dimethoate** **Oxamyl** **Carbaryl** Methidathion Diazinon Formetanate HCL	Dicofol Endosulfan* Fenbutatin-oxide	Abamectin Pyridaben Clofentezine Hexythiazox Fenazaquin+	Horticultural Oils	Release of predacious mites
Lygus and Stinkbugs	**Chlorpyrifos** **Methyl Parathion** **Azinphos-methyl** **Dimethoate** **Oxamyl** **Carbaryl** Formetanate HCL	Esfenvalerate Malathion Methomyl Endosulfan* Fipronil+		Pyrethrins Rotenone Attract and Kill Systems	Suppress weed hosts Trap crops and border sprays+

* Endosulfan and methoxychlor are endocrine disruptors. Future apple uses are in doubt.
\+ Tactic or use not yet labeled and/or under development.
++ The most common species that is effective is *Macrocentrus ancylivorus* (Mahr 1998).

Two or more tactics/products may be required to replace high-risk uses of OPs and carbamates in orchards with dense pest populations. For example, tebufenozide (Confirm) has not provided acceptable control when used alone in Washington State orchards with severe codling moth or leafroller problems. But used in conjunction with mating disruption or an application of *Bt*, the "combination of tactics provided excellent protection of the crop at all locations [tested]," according to Washington State University (WSU) entomologist Jay Brunner (Brunner 1998).

Several new alternatives are available or soon to gain full registration for control of the two pests driving most insecticide use in western apple orchards—codling moth and leafrollers. WSU trials with fenoxycarb (Comply) and spinosad (Success, SpinTor) have had promising results. In his January 1998 review of new chemistry, Brunner states that fenoxycarb "should be an ideal tool to use in IPM systems as a highly selective control against [moth pests] while preserving natural enemies." About spinosad, Brunner reports it "has been shown to provide excellent control of leafrollers and leafminer." Grower interest in alternatives is heightened by WSU data confirming that the effectiveness of both methyl parathion and chlorpyrifos is slipping, and that other high-risk insecticides, including azinphos-methyl, diazinon, dimethoate, and oxamyl, provide "poor or no control" of leafrollers.

PEARS

"Worst 40" Insecticide uses: azinphos-methyl
methyl parathion
phosmet
carbaryl
oxamyl

Production Profile: Three states, California, Washington, and Oregon, accounted for 92 percent of the 70,000 pear-bearing acres in 1995.

Pesticide Use Profile: Ninety percent of the pear acres surveyed by USDA in 1995 were treated with one or more OPs, and 20 percent received one or more carbamate applications. The average pear acre was treated 3.1 times with OPs and carbamates were applied an average of 1.7 times. Because most pear production is within three western states, pest problems are similar, and state-to-state differences in pesticide use are small. Azinphos-methyl is the dominant OP used on pears. Eighty percent of the acreage surveyed by USDA in 1995 was treated with azinphos-methyl, an average of 2.6 times per year. Eight other OPs and carbamates were applied on from three to 16 percent of acres surveyed (Agricultural Chemical Usage: 1995 Fruits Summary, NASS 1996).

Table 3.2. Alternatives to High-Risk OPs and Carbamates Used in Pear Production

	High-Risk OP/Carbamate Uses	Conventional Alternatives	Reduced Risk Alternatives	BioBased Alternatives	BioIPM Practices
PEAR PESTS					
Codling Moth	**Azinphos-methyl** **Methyl Parathion** **Phosmet** **Carbaryl** Chlorpyrifos	Esfenvalerate Malathion Methomyl	Fenoxycarb+ Tebufenozide Pyripoxyfen+ Buprofezin+ Diflubenzuron+ DPX-MP062+	Spinosad+ Neem *Bt* Oils Granulosis virus Pheromones -- Isomate C+, Checkmate CM Sirene CM	Mating Disruption Release of *Trichogramma platneri*
Leafrollers/ Leafminers	**Azinphos-methyl** **Methyl Parathion** **Phosmet** **Oxamyl** **Carbaryl** Dimethoate Diazinon	Esfenvalerate Permethrin Methomyl Endosulfan* Fenbutatin-oxide Malathion	Abamectin Spinosad+ Imidacloprid Tebufenozide+ Fenoxycarb+ Pyriproxyfen+ Buprofezin+	Spinosad *Bt*	Mating Disruption+ Augment, preserve populations of parasites by avoiding broad spectrum sprays
San Jose Scale and Pear Pyslla	**Oxamyl** **Methyl Parathion** **Carbaryl** Dimethoate Diazinon Chlorpyrifos	Esfenvalerate Permethrin Amitraz Endosulfan* Oxythioquinox	Abamectin Fenoxycarb+ Other IGRs+	Spinosad+ Pyridaben Horticultural Azadirachtin Insecticidal Soaps Oils	Plant resistant rootstock Maintain beneficials
Lygus and Stinkbugs	**Methyl Parathion** **Azinphos-methyl** **Carbaryl** **Oxamyl** Chlorpyrifos Dimethoate Formetanate HCL	Esfenvalerate Malathion Methomyl Endosulfan* Fipronil+		Pyrethrins Rotenone Attract and Kill Systems	Trap crops and border sprays+ Reduce weed hosts

* Endosulfan is an endocrine disruptor. Future pear use is in doubt.
\+ Tactic or use not yet labeled and/or under development.

Pest Profile**:** Pests driving OP and carbamate use on pears include: codling moth, San Jose scale, grape mealybug, pear psylla, leafrollers, and mites. Codling moth and the pesticides used to control it are responsible for the lion's share of children's pesticide exposure from pears.

Alternatives to High-Risk OPs and Carbamates*:* Pear growers have many options that would allow them to eliminate or significantly reduce their OP and carbamate use. As Table 3.2 shows, most of the key pests of pears and high-risk insecticides used against them are the same as described in the Apples case study, and many of the same alternatives apply to both crops.

PEACHES

"Worst 40" Insecticide uses:
azinphos-methyl
chlorpyrifos
diazinon
methyl parathion
phosmet
formetanate hydrochloride
aldicarb
carbaryl

Production Profile: Four states, California, New Jersey, Georgia and South Carolina accounted for 65 percent of the nearly 170,000 peach acres nationally in 1995. California alone accounts for 35 percent of all bearing acres (Noncitrus Fruits Summary, NASS 1998).

Pesticide Use Profile**:** Use of OPs and carbamates on peaches is high compared to that on other fruit crops. Nationally, 81 percent of peach acres were treated with an OP an average 4.6 times in 1995, and 29 percent of acres were treated an average 2.3 times with a carbamate. On average, 2.9 pounds of insecticides from these two families were applied per acre in the top four states in 1995, with higher use rates in eastern states and lower rates in California. Methyl parathion is the most widely used insecticide in peach production; roughly half the acres surveyed by USDA in 1995 were treated with this high-risk chemical.

Pest Profile: Pests driving OP and carbamate use on peaches include peach twig borer and San Jose scale, omnivorous leaf roller in the West and plum curculio, oriental fruit moth, rose chafer and various boring insects in the East.

Alternatives to High-Risk OPs and Carbamates: Peach growers have a wide range of available and emerging alternatives. As Table 3.3 shows, many of the pests, high-risk insecticide uses and pest-management alternatives are the same for peaches as those described earlier for apples. As for apples, pest problems and the importance of individual alternatives vary from region to region and state to state.

Table 3.3. Alternatives to High-Risk OPs and Carbamates Used in Peach Production

	High-Risk OP/Carbamate Uses	**Conventional Alternatives**	**Reduced Risk Alternatives**	**BioBased Alternatives**	**BioIPM Practices**
PEACH PESTS					
Peach Twig Borer (PTB)	**Methyl Parathion** **Diazinon** **Chlorpyrifos** **Phosmet** **Carbaryl** Methidathion	Esfenvalerate Permethrin Endosulfan*	Fenoxycarb Tebufenozide Other IGRs+ DPX-MP062+	*Bt* PTB Pheromone Spinosad Narrow range oil	Mating Disruption Predacious mites*** Sustain chalcid wasps
Scale Species	**Chlorpyrifos** **Diazinon** **Carbaryl** **Formetanate HCL** Methidathion Ethion	Malathion	Pyripoxyfen+ Buprofezin+ Diofenalen+ Sulfur	Spinosad Narrow range oil *Beauvaria Bassiana*+	**?**
Omnivorous Leaf Roller (OLR)	**Phosmet** **Diazinon**	Esfenvalerate Permethrin	Tebufenozide Other IGRs+	*Bt* OLR Pheromone Spinosad	Mating Disruption
Oriental Fruit Moth (OFM)	**Azinphos-methyl** **Diazinon** **Phosmet** **Carbaryl**	Methomyl Esfenvalerate	DPX-MP062+ Fenoxycarb	OFM Pheromone Spinosad	Mating Disruption
Plum Curculio	**Azinphos-methyl** **Methyl Parathion** **Diazinon** **Phosmet**	Esfenvalerate	**?**	**?**	**?**
Rose Chafer	**Methyl Parathion**	Esfenvalerate Endosulfan	**?**	**?**	**?**

\+ Tactic or use not yet labeled and/or under development.

* Endosulfan is an endocrine disruptor. Future use is in doubt.

*** An important predacious mite being used in peach orchards is *Galendroma occidentalis*, applied at 2,000 per acre (personal communication, Tom Branson, Sierra Ag, see Appendix A for more details).

GRAPES

"Worst 40" Insecticide uses: azinphos-methyl
chlorpyrifos
dimethoate
formetanate hydrochloride
carbaryl
methomyl

***Production Profile*:** Five states accounted for nearly all of the nation's 754,000 grape-bearing acres in 1995, and California alone accounted for 86 percent. Most of the remaining acres are in Washington, Michigan, New York and Pennsylvania (Noncitrus Fruits and Nuts, NASS 1998).

***Pesticide Use Profile*:** Grape producers rely less on OP and carbamate insecticides than growers of the other four fruit crops in our survey. In 1995, only 18 and 20 percent, respectively, of grape acres surveyed by USDA were treated with one or more organophosphate and carbamate insecticides. Each acre was treated 1.3 and 1.4 times, on average. Insecticide use varies regionally: Less than 20 percent of western grape acreage was treated with an OP or carbamate, but nearly 60 percent of the acres in the three eastern grape-producing states were treated with carbaryl, a typically lower-risk carbamate. But in the case of grapes, we identify carbaryl as a "high-risk" use because residues have been found in over 5 percent of samples tested in recent years (one of the criteria set forth in Chapter 2). The most widely used high-risk insecticide on grapes in California in 1997 was methomyl, which was applied on about 7 percent of acres.

***Pest Profile*:** Pests driving OP and carbamate use on grapes include: Grape berrymoth, grape skeletonizer, mealybugs, omnivorous leafrollers, leafminers, leafhoppers, thrips and mites.

Alternatives to High-Risk OPs and Carbamates: Grape producers have many pest control options. The diversity of choices and the relatively mild pest problems in western vineyards, where IPM is extensively used, mean most growers are already relying primarily on safer alternatives, not high-risk OPs and carbamates. Table 3.4 displays the available choices.

Table 3.4. Alternatives to High-Risk OPs and Carbamates Used in Grape Production

	High-Risk OP/Carbamate Uses	**Conventional Alternatives**	**Reduced Risk Alternatives**	**BioBased Alternatives**	**BioIPM Practices**
GRAPE PESTS					
Grape Berrymoth	**Azinphos-methyl** **Chlorpyrifos** **Carbaryl** **Methomyl** Methyl Parathion Diazinon	Phosmet	Tebufenozide+ DPX-MP062+	Spinosad *Bt* Pheromones	Mating Disruption
Omnivorous Leafrollers	**Carbaryl** **Methomyl** Diazinon	Cryolite Phosmet	Tebufenozide Imidacloprid	*Bt* Pheromones	Cultural Practices (removal of basal leaves)
Grape Skeletonizer	**Azinphos-methyl** **Methomyl**	Phosmet Cryolite	IGRs+	Granulosis virus	Release of Parasites**
Grape Mealybug	**Chlorpyrifos** **Dimethoate** **Azinphos-methyl** Methyl Parathion Naled	Phosmet Malathion	IGRs+	Spinosad Neem Narrow range oil *Bt*+	Release of parasitic wasps++
Leafhoppers **Leafminers**	**Dimethoate** **Methomyl** **Carbaryl** Diazinon Naled	Phosmet Endosulfan* Cryolite	Imidacloprid	Spinosad Insecticidal soaps Pyrethrins *Bt*	Augment lacewing, minute pirate bug, other beneficial insect populations Remove weed hosts

\+ Tactic or use not yet labeled and/or under development.

++ At least five species of parasitic wasps attack Grape mealybug, as well as a ceciodomyiid fly, *Cryptolaemus montourzieri* (Grape mealybug, UC Pest Management Guidelines, see Appendix A for access). In Washington, research is exploring the efficacy of steps to augment populations of *Pseudaphycus websteri* (WSU Tree Fruit Research and Extension Center website, see Appendix A).

* Endosulfan is an endocrine disruptor. Future use is in doubt.

** The two species are *Aoanteles harrisinae* and *Amedoria miselia* (Grape Crop Guide, see Appendix A).

ORANGES

"Worst 40" Insecticide uses: methidathion
chlorpyrifos
carbaryl

Production Profile: Two states, Florida and California, accounted for 95 percent of the nation's orange-producing acreage in 1995. Florida produces oranges primarily for processing (into juice), while most of California's oranges are consumed fresh (Citrus Fruits: 1997 Summary, NASS 1997).

Pesticide Use Profile: Thirty-five percent of orange-bearing acres in 1995 were treated with one or more OPs an average of 1.8 times, and 21 percent were treated with one or more carbamates an average of 1.5 times. OP and carbamates reliance is substantially lower in Florida than in California where cosmetic standards for fresh oranges drive most insecticide use. The average acre in Florida is treated with less than one pound of OPs and carbamates, predominantly at planting or early in the season, reducing the likelihood of residues (C. Mellinger, personal communication). Meanwhile, the average orange acre in California is treated with 4.9 pounds of OPs and carbamates, mostly during the growing season. For example, chlorpyrifos was applied to about half the California orange acres at a rate of 4.8 pounds per acre per year, while in Florida, just 7 percent of acres were treated with chlorpyrifos at a rate of 1.7 pounds per acre per year (Agricultural Chemical Usage: 1995 Fruits Summary, NASS 1996).

Our analysis was largely completed before USDA released pesticide use data for 1997, but the most recent figures show some changes in use patterns for high-risk insecticides on oranges. Chlorpyrifos use in California almost doubled between 1995 and 1997, in part because acres treated with dimethoate, another high-risk OP, declined sharply. In Florida there were across-the-board reductions in high-risk OP and carbamate use between 1995 and 1997. The difference in trends in the two states reflects the sensitivity of fresh-market growers to damage from California red scale, an insect that can cause minor blemishing on the peels of oranges.

Pest Profile: Pests driving OP and carbamate use on oranges include California red scale, citrus leafminer, brown citrus aphid, thrips and in some years, ants.

Alternatives to High-Risk OPs and Carbamates: Several lower-risk alternatives are already in use on much of the orange acreage in Florida and California, and can be drawn upon more widely as high-risk insecticides are phased out. Table 3.5 summarizes these alternatives.

The recent registration of pyripoxyfen will provide California growers a key new tool in managing scale. Other IGRs are also in the development pipeline that show promise in managing citrus pests. We also expect that carbaryl can remain an important insecticide in helping growers manage resistance to pyripoxyfen and other IGRs, as well as in dealing with unexpected outbreaks, assuming EPA structures a series of label changes designed to reduce the frequency and levels of residues. With a well-structured set of label changes, EPA could convert this high-risk use to one posing very modest dietary risk.

Table 3.5. Alternatives to High-Risk OPs and Carbamates Used in Orange Production

	High-Risk OP/Carbamate Uses	**Conventional Alternatives**	**Reduced Risk Alternatives**	**BioBased Alternatives**	**BioIPM Practices**
ORANGE PESTS					
Brown Citrus Aphid	**Chlorpyrifos** **Carbaryl** Diazinon Dimethoate Disulfoton Aldicarb	Fenbutatin Oxide Cyfluthrin	Pymetrozine+ Imidacloprid+ Pyridaben+	Horticultural oil Pyrethrins/ Rotenone Insecticidal Soaps	Maintain beneficials
Scale Species	**Chlorpyrifos** **Methidathion** **Carbaryl** Azinphos-methyl Formetanate HCL Ethion	Malathion	Pyripoxyfen Diofenalen+ Sulfur	Spinosad Narrow range Oil *Beauvaria Bassiana*+	Release of parasitic wasps++ Control ants
Citrus Thrips	**Methidathion** **Carbaryl** Dimethoate Formetanate HCL	Cyfluthrin Fipronil+	Chlorfenapyr Abamectin Pyridaben+	Spinosad Sulfur Sabadilla *Beauvaria Bassiana*+	Predatory Mites Avoid broad spectrum sprays
Ants	**Chlorpyrifos** **Carbaryl** Formetanate HCL		**?**	Pyrethrins Polybutenes on tree trunks	Skirt prune trees Apply sticky materials

\+ Tactic or use not yet labeled and/or under development.

++ Common species recommended for augmentative release in the University of California IPM guidelines include *Aphytis melinus*, *A. lingnanensis*, and *Comperiella bifasciata. Aphytis lepidosaphes* is the most effective parasitic wasp controlling purple scale.

GREEN BEANS

"Worst 40" Insecticide uses: methyl parathion
methamidophos
dimethoate
acephate
carbaryl

***Production Profile*:** Nearly three-quarters of the 304,000 acres of green beans nationwide in 1996 was planted for the processing market. Four states—Wisconsin, Oregon, Michigan and New York—account for 60 percent of the processing bean acreage, with Wisconsin dominating production. Two states, California and Florida, account for over half of the acreage devoted to the fresh market (Vegetables: 1997 Summary, NASS 1998).

Pesticide Use Profile: Sixty-six percent and 33 percent of processing green bean acreage surveyed by USDA in 1996 was treated with at least one OP or at least one carbamate, respectively. OPs were applied an average of 1.8 times per acre and carbamates an average of 1.1 times per acre. OPs dominate insecticide use in the top four states surveyed, accounting for 86 percent of the acre treatments. Nearly one-third of the processing crop surveyed was treated with methyl parathion in 1996. In Wisconsin, where most beans are grown for processing, methyl parathion accounted for half of all the insecticide treatments, acephate for 42 percent, and dimethoate for the remainder. Less toxic OPs tend to be applied to beans produced for the fresh market (Vegetables, 1996 Summary, NASS, July 1997).

Pest Profile: Insects driving OP and carbamate use on green beans included thrips, European corn borer, leafhoppers, aphids, fleabeetles, worms, and stinkbugs.

Alternatives to High-Risk OPs and Carbamates*:* Table 3.6 displays an array of alternatives available for control of these pest problems on green beans. Emerging BioBased alternatives such as spinosad offer great promise for effective control of several major pests on green beans, especially if used in combination with other methods to assure good season-long control and to avoid the emergence of resistance.

Table 3.6. Alternatives to High-Risk OPs and Carbamates Used on Green Beans

	High-Risk OP/ Carbamate Uses	Conventional Alternatives	Reduced Risk Alternatives	BioBased Alternatives	BioIPM Practices
GREEN BEAN PESTS					
Thrips	**Acephate** **Methyl Parathion** Disulfoton	Methomyl	Thiamethoxam+ Pyridaben+	Spinosad Azadirachtin Pyrethrins Horticultural Oil Insecticidal Soaps	Crop rotation
European Corn Borer	**Acephate** **Methyl Parathion** **Dimethoate** **Carbaryl**	Bifenthrin Esfenvalerate Fipronil+ Methomyl	DPX-MP062+	Spinosad Pyrethrins *Bt*	Pheromone Trap Cropping Crop rotation
Leafhoppers **Leafminers**	**Acephate** **Methyl Parathion** **Dimethoate** **Carbaryl** Naled Diazinon Disulfoton Aldicarb	Bifenthrin Esfenvalerate Methomyl Malathion Endosulfan*	Pymetrozine+ Imidacloprid	Pyrethrins Azadirachtin *Bt* Insecticidal Soaps Horticultural Oil Rotenone	Augment, preserve populations of parasites by avoiding broad spectrum sprays Crop rotation
Aphids	**Acephate** **Methyl Parathion** **Dimethoate** **Carbaryl** Diazinon Naled Disulfoton	Bifenthrin Esfenvalerate Permethrin Methomyl	Pymetrozine+ Imidacloprid	Horticultural oil Pyrethrins Insecticidal Soaps Rotenone	Release of lacewings, other beneficials Crop rotation
Bean beetles	**Methyl Parathion** **Acephate** **Azinphos-methyl** **Dimethoate** **Carbaryl** Diazinon Disulfoton	Malathion Bifenthrin Esfenvalerate Endosulfan*	**?**	Pyrethrins Azadirachtin Rotenone	Alter timing of planting Crop rotation
Worms	**Acephate** **Methyl Parathion** **Carbaryl** Diazinon Chlorpyrifos	Methomyl Esfenvalerate Endosulfan* Fipronil+	Tebufenozide Other IGRs+ Pyridaben DPX-MP062+	Spinosad Azadirachtin *Bt* Pyrethrins	Crop rotation Residue management

\+ Tactic or use not yet labeled and/or under development.
* Endosulfan is an endocrine disruptor. Future use is in doubt.

PEAS

"Worst 40" Insecticide uses: dimethoate
acephate

Production Profile: Four states, Minnesota, Wisconsin, Oregon and Washington account for 80 percent of all acreage planted for peas. Minnesota and Wisconsin together, account for over half of the national acreage.

Pesticide Use Profile: Pea producers appear to rely less on OPs and carbamates than growers of other vegetable crops consumed in quantity by children do. Pea growers in Minnesota and Wisconsin reported no use of OPs or carbamates; all reported use of these insecticides in 1996 was applied to Oregon and Washington acreage. Growers there apply the chemicals, on average, just once per growing season. Half the acreage in Washington and Oregon was treated with dimethoate.

Pest Profile: One pest—aphids—drives most use of high risk OPs and carbamates on peas. "Worms" (a generic term often used to describe larvae of Lepidopteran insects, the moths and butterflies) are minor pests of peas.

Alternatives to High-Risk OPs and Carbamates: Table 3.7 displays a range of alternatives for managing this comparatively small cluster of pest problems.

Table 3.7. Alternatives to High-Risk OPs and Carbamates Used in Pea Production

	High-Risk OP/ Carbamate Uses	Conventional Alternatives	Reduced Risk Alternatives	BioBased Alternatives	BioIPM Practices
PEA PESTS					
Aphids	**Acephate** **Dimethoate** Diazinon Methyl Parathion	Esfenvalerate Methomyl Malathion Bifenthrin+	Pymetrozine Imidacloprid	Spinosad Horticultural oil Pyrethrins Insecticidal Soaps	Crop rotation Avoid fungicide sprays that damage fungi
Lepidopteran Pests/Worms	**Acephate** **Dimethoate** Methyl Parathion	Esfenvalerate Methomyl Carbaryl Bifenthrin+	Tebufenozide+ Pyripoxyfen+ Other IGRs+ Imidacloprid DPX-MP062+	Spinosad *Bt*	Crop rotation Residue management

+ Tactic or use not yet labeled and/or under development.

Potatoes

"Worst 40" Insecticide uses: methamidophos
aldicarb

Production Profile: Six states account for 80 percent of the acreage planted to fall potatoes. Idaho is the industry leader, accounting for about one-third of all acreage. Washington, North Dakota, Minnesota, Wisconsin, and Maine also account for significant shares of national production.[1]

Pesticide Use Profile: OPs and carbamates were used on 52 percent and 50 percent respectively of the fall potato acres surveyed by USDA in 1997. OPs were applied an average 1.6 times and carbamates, 1.3 times. Methamidophos, azinphos-methyl, dimethoate, phorate, carbofuran, and aldicarb are the predominant insecticides of these families used in potato production.

Since the edible portion of a potato crop remains below the ground until harvest, pesticides applied during the growing season rarely leave residues in the food as consumed. An exception is systemic pesticides (which are taken up by plants and transported into all growing tissue). Aldicarb is a systemic insecticide.

Aldicarb, the most acutely toxic pesticide on the market, is used on a small but growing percentage of potato acreage. Growers in Idaho applied, on average, 2.6 pounds of aldicarb per acre on 11 percent of planted acreage in 1997, an increase from only 1 percent in 1996. Washington potato producers applied aldicarb to 28 percent of acres planted in 1997, up from 18 percent in 1996.

Insecticide use trends vary markedly among potato-producing states. The intensity of use is rising in Idaho, is falling in Wisconsin, North Dakota, and Maine, and is stable in other states. Wisconsin growers, in particular, have significantly reduced reliance on high-risk OPs and carbamates.[2] In just two years, Wisconsin growers phased out use of three high-risk insecticides—azinphos-methyl, carbofuran and oxamyl—and reduced methamidophos use by 75 percent. During the same period, use of high-risk insecticides in Idaho increased substantially.

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[1] Colorado is also a major potato producing state but was not included in our analysis because NASS did not collect pesticide use data on potatoes for Colorado in 1997.
[2] For details see "Attainment of 1997 Industry-wide Pesticide Risk Reduction Goals: Technical Report to WWF and WPVGA," Charles Benbrook, June 1998. For a copy, call WWF at 202-778-9781.

Pest Profile: Major pests driving OP and carbamate use in the major potato production areas are the green peach aphid and the Colorado potato beetle, two pests that have grown resistant to several OP and carbamates in many producing regions, heightening interest in IPM and new insecticides. Wire worms and nematodes, non-insect pests, also account for some use of high-risk OPs in western states.

Alternatives to High-Risk OPs and Carbamates: Integrated pest management, combining cultural practices such as soil nutrient management, weed control, applications of microbial bioinsecticides, and use of lower risk chemicals, has already been adopted by many potato producers. The preferred lower-risk insecticide imidacloprid (Admire) has made a major difference, reducing reliance on methamidophos in managing the green peach aphid and reducing use of several high-risk insecticides applied for Colorado potato beetle. Resistance to this new chemical has become a concern, and growers will continue to need an array of alternatives. Table 3.8 displays the major alternatives currently available for potato insect control.

Table 3.8. Alternatives to High-Risk OPs and Carbamates Used in Potato Production

	High-Risk OP/ Carbamate Uses	Conventional Alternatives	Reduced Risk Alternatives	BioBased Alternatives	BioIPM Practices
POTATO PESTS					
Green Peach Aphid	**Methamidophos** Azinphos-methyl Carbofuran Diazinon Dimethoate	Methomyl Malathion Esfenvalerate Permethrin Endosulfan*	Pymetrozine Imidacloprid Abamectin Pirimicarb+	Spinosad Horticultural oil Pyrethrins	Crop rotation Managing nutrients to deter aphid feeding Release of *Aphelinus asychis*++
Colorado Potato Beetle	**Aldicarb** **Methamidophos** Azinphos-methyl Diazinon Disulfoton Carbofuran Phorate Fonofos	Carbaryl Endosulfan* Fipronil+	Imidacloprid Tebufenozide+ Methoxyfenozide+ DPX-MP062+	*Beauvaria Bassiana* Spinosad *Bt* Pyrethrins	Crop rotation Landscape management Barriers to Beetle movement Microbes that alter freezing temperature**

* Endosulfan is an endocrine disruptor. Future use is in doubt.
** Under development at the University of Wisconsin to lower the freezing temperature of beetles during the fall and overwintering period, an area-wide population suppression tactic.
\+ Tactic or use not yet labeled and/or under development.
++ An adapted strain of parasitoid found in France, under development by Washington State University entomologists.

Spinosad is now registered for potato use as a primary control for aphids and a supplemental tool in Colorado potato beetle management. Fipronil, another new active ingredient with a novel mode of action, showed the best early season control of Colorado potato beetle of any insecticide tested by the University of Washington in 1997 trials (Long 1998). Thiomethoxam, another nicotinoid, is also likely to be valuable used in rotation with other insecticides in managing this major pest.

Tomatoes

"Worst 40" Insecticide uses: azinphos-methyl
chlorpyrifos
methamidophos

Production Profile: Two states, Florida and California, account for more than half of the 128,000 acres planted for fresh market tomatoes. California alone accounts for 92 percent of the 345,000 tomato acres planted for processing nationally. Our analysis focuses on fresh tomatoes, but pest problems and management alternatives for processing tomato producers are similar.

Pesticide Use Profile: In USDA's 1996 survey, 55 percent of the fresh tomato acres were treated with one or more OPs, and 59 percent were treated with one or more carbamates. OPs were applied an average of 3.8 times, carbamates 2.8 times per acre. Methamidophos was used on 47 and 66 percent of fresh tomato acres in Florida and California in 1996, respectively. Late-season applications account for the relatively high frequency of methamidophos residue detection on tomatoes. Azinphos-methyl was applied to 14 percent of fresh tomato acres in New Jersey, but no use was reported in the major tomato producing states.

Chlorpyrifos residues were found in about 10 percent of tomatoes tested by the PDP in 1996. Most of the residues are very likely in imported tomatoes. USDA reported no use of chlorpyrifos on tomatoes in 1996. USDA's 1994 vegetable survey found extensive chlorpyrifos use on Florida tomatoes. It appears, therefore, that in this case a substantial shift away from a high-risk insecticide in the U.S. was not matched by at least some foreign growers.

Table 3.9. Alternatives to High-Risk OPs and Carbamates Used in Tomato Production

	High-RiskOP/ Carbamate Uses	Conventional Alternatives	Reduced Risk Alternatives	BioBased Alternatives	BioIPM Practices
TOMATO PESTS					
Aphids	**Methamidophos** Diazinon Dimethoate Oxamyl	Endosulfan* Lindane Esfenvalerate Cyfluthrin Cyhalotrin Malathion Methomyl Fipronil+	Imidacloprid Pymetrozine+ Fenoxycarb+	Spinosad Horticultural oil Pyrethrins Rotenone Insecticidal Soaps	Maintain predators Reflective mulches Avoid damage to beneficial fungi Crop rotation
Whiteflies	**Azinphos-methyl** **Methamidophos** Oxamyl	Permethrin Esfenvalerate Cyfluthrin Cyhalotrin Malathion Endosulfan* Methomyl Fipronil+	Imidacloprid Pyridaben+ Thiomethoxam+	Spinosad *Beauvaria Bassiana* Insecticidal Soaps Azadirachtin Pyrethrins	Reflective mulches Enhance populations of predacious wasps Plant away from alternative hosts
Lepidopteran Pests/Worms	**Methamidophos** **Chlorpyrifos** **Azinphos-methyl** Diazinon	Fenpropathrin Carbaryl Methomyl Endosulfan* Esfenvalerate Cyfluthrin Cyhalotrin Permethrin	Imidacloprid Chlorfenapyr Tebufenozide Emamectin benzoate Thiomethoxam+ DPX-MP062+	Spinosad *Bt* Azadirachtin NPV Tomato Pinworm Pheromone Pyrethrins	Mating Disruption Release of parasitic wasps++ Tillage to destroy residues Crop rotation
Leafminer	**Azinphos-methyl** Dimethoate Diazinon Acephate Oxamyl	Bifenthrin Cyromazine Esfenvalerate Cyfluthrin Cyhalotrin Permethrin Carbaryl Methomyl Malathion Endosulfan*	Abamectin Emamectin benzoate Chlorfenapyr Tebufenozide+ Thiomethoxam+	Spinosad Pyrethrins Horticultural Oils	Crop rotation Build populations of non-damaging species
Mites	Oxamyl Disulfoton	Dicofol Malathion Endosulfan*	Abamectin Pyridaben Fenazaquin+	Sulfur Horticultural Oils	
Thrips	**Methamidophos** **Chlorpryifos** **Azinphos-methyl** Oxamyl	Esfenvalerate Permethrin Cyfluthrin Malathion	Imidacloprid	Spinosad *Bt* Sulfur Pyrethrins Horticultural Oils Insecticidal Soaps	

* Endosulfan is an endocrine disruptor. Future use is in doubt.
\+ Tactic or use not yet labeled and/or under development.
++ For Tomato fruitworm, the dominant parasite is *Trichogramma pretiosum* (see Appendix A for details).

Pest Profile*:* In Florida, leafminers and whiteflies can spread damaging viral diseases. Lepidopteran pests, such as armyworms also can trigger the need for OP and carbamate applications. In California, aphids drive most OP and carbamate use. Secondary pests include mites and thrips.

Alternatives to High-Risk OP and Carbamates*:* Reliance on high-risk OPs and carbamates on tomatoes has been declining for a number of years as growers have attempted to lessen secondary pest problems induced by broad-spectrum insecticide use and manage resistance. A number of sophisticated, multitactic pest management systems have developed. Viable reduced risk alternatives are not only registered for use on fresh tomatoes, but they are already in use in most tomato operations. Some important new products have also recently come onto the market. Accordingly, the decline in use of high-risk OPs and carbamates on tomatoes should continue. The range of current alternatives is displayed in Table 3.9.

Prospects for Adoption of Alternatives

Biologically-based, multitactic pest management systems are available to control nearly all insect pests in the nine crops we studied, and a growing percentage of growers are adapting them to their unique operations. These IPM systems minimize the need for high-risk OP and carbamate uses through tactics like mating disruption, applications of IGRs, and targeted applications of biopesticides like *Bt* or spinosad. Where pest problems are already severe or becoming so, these tactics are generally augmented with changes in cultural and BioIPM practices that diversify or enhance populations of beneficials.

Farmers are developing and adopting such systems because they are more resilient and effective. Managed well, they reduce the risk of resistance and lessen the need for costly and hazardous applications of high-risk chemicals. But the alternatives are typically more complicated than those based on OP or carbamate use; they strive to spread the burden of managing insects across a number of sometimes-redundant practices and tactics.

Overall, there is a positive trend away from broad-spectrum insecticides, and a healthy pace of innovation. USDA’s 1997 fruit and 1996 vegetable pesticide use data show that reliance on high-risk OPs and carbamates is approaching zero in more than a third of our Worst 40 crop-insecticide combinations; as noted earlier, no use was reported in six cases.

But some pesticide companies are fighting hard to preserve or expand market share by aggressive defense of their products and by further lowering the already typically modest price of certain high-risk OP and carbamate products. The recent comeback of aldicarb use on potatoes and the marked upward trends in methyl parathion and chlorpyrifos use on key crops since 1995 are signs of this sobering trend. Patterns of *increasing* OP and carbamate use accentuate the need for EPA to move forward and implement the FQPA. If progress stalls, OP and carbamate risks might well rise in at least a few of the crops studied, including potatoes, pears and apples.

No heroic assumptions are required to identify ample alternatives to the Worst 40 food-insecticide combinations for nearly all the crops and insects we surveyed. The only major exceptions are plum curculio management in eastern apple and peach production, and control of some invading adult insects in certain circumstances on other crops. The alternatives now available to manage these pests reduce the risks associated with high-risk OP and carbamate insecticide use much less dramatically than in most other cases.

Prospects are brightest for growers dealing with aphids, mites, and most of the Lepidopteran pests—typically the toughest insect pests facing fruit and vegetable farmers. In 1999 most growers will have several valuable new options that were not available when the FQPA was passed in 1996. Many more will be available in the next five to 10 years. By integrating two, three or more new products and tactics into their IPM systems, many growers are having a relatively easy time phasing out most high-risk OP and carbamate use, and generally can do so incrementally over a three-to-five-year period without jeopardizing crop yields, quality, or profitability. Most of the farmers who have made the transition are glad to be rid of disruptive high-risk insecticides.

The FQPA provides an opportunity and an incentive for growers to build on the success that many have already achieved, to share experiences with safer insect pest management systems, and to accelerate progress away from dependence on the high-risk OP and carbamate insecticides. The sooner this transition is completed, the better off farmers and children will both be.

Chapter 4

RECOMMENDATIONS

Eliminate the Worst First by Targeting Regulation and IPM Implementation Programs

Amid the controversy and scientific uncertainties over how and when EPA will implement the Food Quality Protection Act, the question of what EPA *can do now* to reduce dietary risk to infants and children has been lost. Our conclusion? A lot.

Many in industry are urging EPA to postpone action until consensus is reached on a host of difficult FQPA science policy issues and even then to act only when there is complete data on all potential health risks and from all routes of exposure – in other words, never.

We recommend a different course of action.

(1) EPA should phase-out high risk OPs and carbamates used on children's foods

EPA should expeditiously complete their FQPA safety review of OPs and carbamates and take action to reduce known significant sources of children's risk immediately. Upon determining that these high-risk insecticides, either individually or as a class, exceed the FQPA safety standard, EPA should phase out over a two-year period the three to four dozen highest risk uses for which safer pest management alternatives exist. While the agency has flexibility in determining which food uses will be canceled when an insecticide, or class of products, exceeds the FQPA safety standard, both common sense and the mandate of the Act dictate that EPA should first target those relatively few uses which pose clearly significant risks to infants and children.

Additional use or exposure data, or more research on risk assessment methods are not going to change the well-documented fact that some current uses of the most toxic OPs on crops like apples and pears will continue to result in exposure and risks to children far above what can be accepted under the FQPA's safety standard. This conclusion would remain inescapable even if essentially all other OP uses were canceled to maximize the room available in the risk cup, clearly a policy option without merit.

During the first year of the phase out, EPA should require label changes to the highest risk insecticide uses to incrementally reduce risk to children as growers still reliant on these chemicals transition to safer alternatives. The riskier the use, the greater the label changes EPA should impose. Some changes should be made this winter and apply to the next crop season. Without action this winter, children are likely to face ***rising*** exposures to some of the highest risk insecticides including methyl parathion, chlorpyrifos, and aldicarb from consumption of key foods needed for a healthy diet.

Timely and targeted action to reduce exposures from the Worst 40 uses will be even more important as the agency completes its cumulative risk assessment of organophosphates. EPA officials have already stated that solid evidence shows that the total exposure to OPs will likely exceed safe levels. No one knows yet by how much, and hence what combination of actions will be needed to reduce exposures to an acceptable level. But eliminating exposures from the Worst 40 uses must remain a top priority as the cumulative risk assessment is refined. Action now will lessen the FQPA's impact on other food uses that contribute less significantly to risk and would ensure that regulatory and private sector resources are wisely targeted. Furthermore, our analysis shows that targeting regulatory action at the Worst 40 will have little or no impact on the food supply given the diversity of safer pest management alternatives that growers will be able to draw upon.

EPA must also address risk to infants and children from other potentially significant sources of exposure to these high-risk insecticides, such as in drinking water and through home use. But the agency should not delay action to reduce known sources of dietary risk to children as it determines how to implement these other essential provisions of the FQPA. EPA has both the data and the scientific knowledge to begin phasing out OP and carbamate food uses that drive risk to infants and children. All it lacks is the political will.

(2) EPA must reduce or eliminate residues from *all* OP and carbamate uses on key children's food to assure significant – and sustained -- risk reduction

To reduce overall dietary exposure and risk effectively, EPA must take a systematic approach toward regulating all OP and carbamate food uses. It will not be enough to merely phase out the Worst 40 uses; if other OPs and carbamates are substituted for the current Worst 40 uses, regulation will only shift risk and will not substantially reduce it.

In Chapter 3, we found an adequate set of non-OP and non-carbamate alternatives for all but one of the Worst 40 uses – management of the plum curculio in eastern apple orchards. In addition some uses of less toxic OPs and carbamates (such as carbaryl, phosmet and malathion) will continue to play an important role in IPM systems in some crops. For example, these chemicals will continue to be needed for limited rescue treatments and to help manage resistance to the new, very low risk products.

Decisions to permit continued use of less-toxic OPs and carbamates *must* be part of a carefully crafted overall strategy designed to eliminate or markedly reduce the frequency and level of residues remaining in food. EPA should work with growers, food processors and registrants to revise label directions with the goal of eliminating detectable residues.

A solid step toward this goal would be an immediate across-the-board increase of one week in the amount of time between when growers apply these insecticides and when the crop can be harvested (often referred to as a "Pre-harvest Interval"). This simple, common sense step should be coupled with stricter limitations on late-season insecticide application rates. In revising labels to reduce the chances of residues in food, EPA should also review and update field reentry intervals and other label provisions designed to assure ample margins of safety for farm workers, pickers and pesticide applicators.

(3) USDA and Congress should fund farmer education on safer alternatives to the Worst 40 uses

Our analysis in Chapter 3 identified many viable alternatives to high-risk OP and carbamate uses that farmers can use to manage insect pests. Many growers of key children's foods have already adopted them, but others are not yet aware of the particular circumstances and factors governing the cost-effective use of alternatives. Cost-effective and reliable alternatives typically include a combination of cultural, biological and chemical controls. Their adoption entails a learning curve. The transition toward biologically based Integrated Pest Management (IPM) takes time and effort. Some farmers will need technical assistance as they move forward with the transition away from routine use of high-risk chemicals.

USDA and Congress must significantly increase funding devoted to on-farm IPM educational and implementation efforts, focusing first on crops and pests associated with "Worst First" uses. Our analysis shows that for most of the Worst 40, research on IPM-based alternatives and innovation in the pesticide industry have produced a number of viable alternatives. Attention must turn now to the key step of integrating alternatives into ongoing farm operations in ways that threaten neither production nor profit margins.

While this report was in production, Congress allocated over $1.6 billion for agricultural research and education for Fiscal Year 1999 but only $11 million for implementation of

Integrated Pest Management – most of which goes to support salaries and expenses for IPM coordinators for each state, not actual technology transfer projects. The Sustainable Agriculture Research and Extension (SARE) program has supported a number of valuable on-farm IPM education projects in several states but has also been badly under funded since it was authorized more than a decade ago.

Since the FY 1997 budget cycle, Congressional appropriators have given lip service to the special challenges posed by the FQPA, but no new money has been approved. This year they chose to not even target existing funds toward the highest priority crops and pests.

Starting with FY1999 and throughout the two-year phase out of the Worst 40 uses, Congressional appropriators should provide at least $40 million to USDA's IPM and SARE programs in FY1999 and subsequent years for technology transfer and on-farm education efforts regarding safer alternatives to high-risk insecticide uses, with a significant portion directed toward the Worst 40 high-risk OP and carbamate uses we have identified. Funding increases could be offset by reducing spending on earmarked grants for individual research institutions under the Special Research Grants Program within the Cooperative Research, Extension and Education Service.

(4) EPA should expedite registration of safer alternatives to OPs and carbamates

Several of the key alternatives to the Worst 40 insecticide uses identified in Chapter 3 are not yet fully registered by the EPA for use on key fruit and vegetable crops. EPA should give high priority to registering safer "reduced risk" alternatives and biopesticides that fully meet the FQPA's safety standard, especially those that will facilitate the phase-out of high-risk insecticides and speed the transition to biointensive IPM.

In this regard, important registration actions pending before EPA include:

- Spinosad
- Pymetrozine
- DPX-MP062
- Thiamethoxam
- Insect growth regulators including tebufenozide and pyripoxyfen

(5) USDA and Congress should double funding for research on Integrated Pest Management and safer alternatives

Even as EPA phases out the Worst 40 OP and carbamate uses for which alternatives exist and eliminates residues from less toxic OPs and carbamates, more must be invested in research to discover and refine even safer and more reliable biologically based techniques to manage insect pests. Like funding for IPM implementation, federal spending for research on new IPM technologies has been woefully inadequate. In FY1998, just over $10 million in federal funding was allocated to support IPM systems research.

USDA should request and Congress should appropriate each year at least twice the historical funding levels for the CSREES IPM program, the Pest Management Alternatives Program, and area-wide IPM research in the Agricultural Research Service. New research must be targeted to high-risk insecticide uses, particularly those not phased out in the next two years because of the lack of alternatives.

Conclusion

The Food Quality Protection Act made sweeping changes in the way EPA protects Americans, including 19 million under the age of five, from pesticides in the food supply. More than two years have passed since the Act became law. Nearly ten years have gone by since Congress first requested what became the groundbreaking NRC Report *Pesticides in the Diets of Infants and Children*, the document that provided the scientific basis for the FQPA's mandate to protect infants and children. But political maneuvering and resistance from affected interests now threaten to postpone badly needed gains in public health protection for many years more.

EPA must carry out the will of the American people, as expressed by Congress in unanimously passing the FQPA in the summer of 1996. It must take clear and decisive steps to reduce known dietary exposure of infants and children to high-risk insecticides. The agency has the sound scientific information it needs to shape and justify decisions focusing on the worst first. FQPA gives them the authority and the obligation to break the gridlock of the past decade and move forward at last.

It is time to get on with it.

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U.S. Department of Agriculture, National Agricultural Statistics Survey/Economic Research Service (1998). ***Noncitrus Fruits and Nuts -- 1997 Preliminary Summary***. Fr Nt 1-3 (98) a, Washington DC. (See Appendix A for access via the Internet).

U.S. Department of Agriculture, National Agricultural Statistics Survey/Economic Research Service (1997). ***Citrus Fruits: 1997 Summary***. Fr Nt 7 (97), Washington DC. (See Appendix A for access via the Internet).

U.S. Department of Agriculture, National Agricultural Statistics Survey/Economic Research Service (1998). ***Vegetables: 1997 Summary***. Vg 1-2 (98), Washington DC. (See Appendix A for access via the Internet).

Appendix A. Sources of Information on Alternatives to High-Risk Insecticides

Information on current uses of organophosphate and carbamate insecticides and alternatives was compiled from several sources and experts.

Pesticide use data were obtained from the U.S. Department of Agriculture via the National Agricultural Statistics Service (NASS). It is accessible in electronic format via a site maintained at Cornell University's Mann Library. For a list of NASS chemical use survey documents available over the Internet, go to: http://jan.mannlib.cornell.edu/reports/nassr/other/pcu-bb/

Data on the acres planted to various crops and production are reported in another NASS data series. Information on fruit acreage, for example, was obtained from **Noncitrus Fruits and Nuts: 1997 Preliminary Summary.** To access this and similar reports on other crops, go to: http://usda2.mannlib.cornell.edu/reports/nassr/fruit/pnf-bb/noncitrus_fruits_and_nuts_preliminary_01.22.98

Through a contract with the EPA, Leonard Gianessi, National Center for Food and Agricultural Policy, Washington, D.C., compiled an Access database on organophosphate and carbamate uses entitled "The Use of OP Insecticides in U.S. Crop Production." The database covers most major food uses of OP insecticides and provides details on use patterns, extent of use, and alternatives. Information in the database is from a number of experts in academia, commodity organizations and pesticide manufacturers. A preliminary version was used as a source of information on several of the crops studied.

New and Recently Registered Alternatives

A presentation entitled "New Generation of Insecticides with Novel Chemistry: Looking Toward an Exciting Future" by Dr. Larry Larson, Insect Management Discovery Research, Dow AgroSciences was helpful in identifying possible uses of new and emerging insecticides. Dr. Larson provided further information in a series of phone conversations.

The "Reduced Risk Rationale Document" accompanying the Novartis petition to establish tolerances for food uses of the new aphicide pymetrozine, dated October 1997, contains extensive information on the use and benefits of this chemical, including several tables comparing pymetrozine uses to currently registered OPs, carbamates and synthetic pyrethroids.

Information on spinosad was obtained from several sources including the "Reduced Risk Rational" submission dated February 15, 1995, as well as the document "Reduced-Risk Rational for Spinosad, a Fermentation-Based Product for the Control of Insects on Cotton," by Robert Bischoff, Dow AgroSciences (RFB 112294, dated September 28, 1994).

An excellent review of the importance of three new insecticides on emerging apple IPM alternatives in the West has been compiled by Dr. Jay Brunner, WSU Treefruit Research and Extension Center, Wenatchee, Washington. "Codling Moth and Leafroller Control with New Insecticide Chemistry" is accessible at: http://www.tfrec.wsu.edu/staff/jfb/growerarticles/newchems/newchems.pdf

Extensive information on pheromone and *Bt*-based IPM alternatives for use in managing major pests in California fruit crops is available on the website of Sierra Ag, based in Fresno, California: http://www.sierraag.com/
The role and uses of beneficial insects, including rates of releases and pricing information, is at: http://www.sierraag.com/insects/insects.htm
Detailed information on pheromone traps, lures and mating disruption in pears, peaches, apples, almonds, grapes and other crops can be found at: http://www.sierraag.com/lure/lure.htm
The "Frequently Asked Questions" provide helpful, general guidance for growers working to lessen reliance on broad-spectrum products, and offers much practical advice on the transition: http://www.sierraag.com/faq/faq.htm

Individuals Providing Information on Pests and Control Alternatives

Individuals providing information included Dr. Neal Anderson, Office of Pesticide Programs, U.S. EPA, Washington, D.C.; Dr. Edward Bechinski, University of Idaho, Moscow, Idaho; Mr. Tom Branson, Sierra Ag, Fresno, California; Dr. Robert Brown, Troy Biosciences, Phoenix, Arizona; Dr. William Chaney, University of California; Dr. Harold Coble, USDA IPM Coordinator, Washington, D.C.; Ms. Jennifer Curtis, consultant to NRDC, Chapel Hill, North Carolina; Mr. Kert Davies, Environmental Working Group, Washington, D.C.; Dr. Jeff Dlott, U.S. EPA Region 9; Mr. Brian Flood, Del Monte Research, Wisconsin; Dr. Pete Goodell, IPM Entomologist, University of California, Parlier, California; Mr. David Granatstein, Center for Sustaining Agriculture and Natural Resources, Washington State University; Dr. Patrick Greany, USDA-ARS Insect Attractants, Behavior and Basic

Biology Research Laboratory, Gainesville, Florida; Dr. Larry Gut, Michigan State University; Dr. Michael Hansen, Consumers Union, Yonkers, New York; Dr. Paul Jepson, Oregon State University, Corvallis, Oregon; Dr. Philip Kirsch, IPM Technologies, Inc., Portland, Oregon; Dr. Jamie Liebman, U.S. EPA Region 9; Mr. Mark Lipson, Organic Farming Research Foundation, Santa Cruz, California; Dr. Pam Marrone, AgraQuest, Davis, California; Dr. Charles Mellinger, Glades Crop Care, Jupiter, Florida; Dr. Cliff Ohmart, Lodi-Woodbridge Wine Grape Commission; Dr. Ed Rajotte, University of Pennsylvania; Dr. Ann Sorensen, Center for Agriculture and the Environment, Dekalb, Illinois; Mr. Don Thomson, consultant to 3M Company, Seattle, WA; Mr. Randy van Haren, Pest Pros, Plainfield, Wisconsin; Mr. Pat Weddle, Placerville, California; Dr. Jeff Wyman, University of Wisconsin-Madison; Mr. Dean Zuleger, Heartland Farms, Antigo, Wisconsin.

Internet and Academic Information on Pests and Control Alternatives

The University of California Statewide IPM Project Home Page is an excellent and comprehensive source of information on insect pest biology, current control measures, and emerging alternatives. Resources on this page were used in several case studies, and are accessible at: http://axp.ipm.ucdavis.edu/ Click on Pest Management and Identification to go to:
http://axp.ipm.ucdavis.edu/PMG/uc_pmg.html and then to Pests of Agricultural Crops: http://axp.ipm.ucdavis.edu/PMG/crops-agriculture.html
This site has an extensive list of crops with links to major types and sources of information. This site was a major source of background information in identifying alternatives in California case studies.

Comparable information on many crops and insects is accessible on the University of Florida's branch of the National IPM Network: http://hammock.ifas.ufl.edu/
Or visit: http://WWW.IFAS.UFL.EDU/~FAIRSWEB/IPM/index.htm
The IFAS site has useful, comprehensive lists of all registered and currently used insecticides and biocontrol products organized by crop and pest. Additional information is available through many links built into the site.

The New York State IPM home page provides extensive information on insect pest management challenges in the Northeast: http://www.nysaes.cornell.edu/ipmnet/ny/
It contains information on vegetables, fruits, and field crops.

The University of Michigan IPM site offers helpful fact sheets for a number of insect pests: http://www.msue.msu.edu/vanburen/generali.htm

The University of Minnesota Extension Service IPM home page has extensive information on a variety of crops and IPM system components: http://www.extension.umn.edu/~vegipm/

The National Integrated Pest Management Information System has been developed by the Washington State University College of Agriculture and Home Economics: http://IPM.wsu.edu/ This site has links to information by crop and pest. Extensive information on apple IPM alternatives is presented on the WSU—Tree Fruit Research and Extension Center's website: http://www.tfrec.wsu.edu/

Apples

California insects and alternatives:

Coddling moth	http://axp.ipm.ucdavis.edu/PMG/r4300111.html
Apple maggot	http://axp.ipm.ucdavis.edu/PMG/r4300511.html
Fruittree leafroller	http://axp.ipm.ucdavis.edu/PMG/r4300811.html
Obliquebanded leafroller	http://axp.ipm.ucdavis.edu/PMG/r4301011.html
Omnivorous leafroller	http://axp.ipm.ucdavis.edu/PMG/r4300911.html
Lygus	http://axp.ipm.ucdavis.edu/PMG/r4300411.html

Michigan insect pest assessments:

Rosy apple aphid	http://www.msue.msu.edu/vanburen/fraa.htm
Plum curculio	http://www.msue.msu.edu/vanburen/plumcurc.htm
White apple leafhopper	http://www.msue.msu.edu/vanburen/walh.htm
Apple maggot	http://www.msue.msu.edu/vanburen/fappmag.htm
Codling moth	http://www.msue.msu.edu/vanburen/fcodmoth.htm

Grapes

Grape Crop Guide, California-Arizona Farm Press, Fresno, California.
Integrated Pest Management Field Handbook For Napa County, 1st Edition 7/23/97. By The Napa Sustainable Winegrowing Group.

California pests and alternatives:

Leafhoppers	http://axp.ipm.ucdavis.edu/PMG/r302300111.html
Omnivorous leafroller	http://axp.ipm.ucdavis.edu/PMG/r302300311.html
Grape mealybug	http://axp.ipm.ucdavis.edu/PMG/r302300711.html
Thrips	http://axp.ipm.ucdavis.edu/PMG/r302300911.html

Michigan pests and management systems:

Grape berry moth	http://www.msue.msu.edu/vanburen/grpmth.htm

Washington pests and management options:
Grape mealybug
http://www.tfrec.wsu.edu/InsectRef/GMBug/GMBug.html

Oranges

California pests and management systems:

Ants	http://axp.ipm.ucdavis.edu/PMG/r107300211.html
Red and yellow scale	http://axp.ipm.ucdavis.edu/PMG/r107301111.html
Purple scale	http://axp.ipm.ucdavis.edu/PMG/r107301211.html
Brown soft scale	http://axp.ipm.ucdavis.edu/PMG/r107301311.html
Thrips	http://axp.ipm.ucdavis.edu/PMG/r107301711.html

Florida pests and management options:
1998 Florida Citrus Pest Management Guide: Other Insect Pests
http://hammock.ifas.ufl.edu/txt/fairs/19319

1998 Florida Citrus Pest Management Guide: Scale Insects
http://hammock.ifas.ufl.edu/txt/fairs/19318

Pears

"Guthion use in pear crop all but ends". ***Trees & Vines EXTRA***, California-Arizona Farm Press, Saturday June 29, 1998.

California insects and options:

Fruittree leafroller	http://axp.ipm.ucdavis.edu/PMG/r603300411.html
Obliquebanded leafroller	http://axp.ipm.ucdavis.edu/PMG/r603300511.html
Omnivorous leafroller	http://axp.ipm.ucdavis.edu/PMG/r603300611.html
Codling moth	http://axp.ipm.ucdavis.edu/PMG/r603300111.html
Mealybugs	http://axp.ipm.ucdavis.edu/PMG/r603301211.html
San Jose scale	http://axp.ipm.ucdavis.edu/PMG/r603301311.html

Washington insects and alternatives:
Pesticide resistance management in pear IPM systems
http://www.tfrec.wsu.edu/summary/JED.html

Peaches

California insects and management systems:

Lygus	http://axp.ipm.ucdavis.edu/PMG/r602300511.html
Oriental fruit moth	http://axp.ipm.ucdavis.edu/PMG/r602300211.html
Peach twig borer	http://axp.ipm.ucdavis.edu/PMG/r602300611.html

Snap Beans

Chapter Three, "Beans," by Brian Flood, Gary Hein, and Rick Weinzierl, in ***Vegetable Insect Management***. Edited by Rick Foster and Brian Flood, Meister Publishing, Willoughby, Ohio.

Florida insects and management options:
http://hammock.ifas.ufl.edu/txt/fairs/ig/8239.html

Peas

Minnesota insects and management systems:
Cabbage aphids http://www.mes.umn.edu/~vegipm/vegpest/colecrop/aphid.htm

Potatoes

Minnesota insects and options:
Aster leafhoppers http://www.mes.umn.edu/~vegipm/vegpest/colecrop/aster.htm

Washington insects and management systems:
Colorado potato beetle http://coopext.cahe.wsu.edu/infopub/eb0919/eb0919.html
Insect Pest Management, Where are we now?
http://IPM.wsu.edu/SpudBugs/IPMwherenow.html
Integration of Biological and Chemical Controls in Potato
http://IPM.wsu.edu/SpudBugs/IPPC.html
Colorado Potato Beetle Report 1997 Season
http://ipm.wsu.edu/SpudBugs/Repts97/CPB97Report.html

Tomatoes

California insects and diseases:

Potato aphid	http://axp.ipm.ucdavis.edu/PMG/r783301711.html

Green Peach Aphid and Other Early Season Aphids
http://axp.ipm.ucdavis.edu/PMG/r783300711.html

Tomato fruitworm	http://axp.ipm.ucdavis.edu/PMG/r783300111.html
Hornworms	http://axp.ipm.ucdavis.edu/PMG/r783301111.html

Florida insects and alternatives:
Insect Management in Tomatoes, see FL IPM home page at
http://hammock.ifas.ufl.edu/

New York insects and options:
Control of Insect Pests of Tomatoes
http://pmep.cce.cornell.edu/recommends/vegrecommends-lib/tom.ins.veg96.html

Appendix B. Insecticides Ranked by Chronic Toxicity and Extent of Use

Table 1 presents data on insecticides used in the production of fruit and vegetables, as reported by the most recent chemical use surveys carried out by the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS).

The fruit and vegetable crops surveyed by NASS in 1996 and 1997 are shown in Table 2. Fruit data were collected in crop season 1997, vegetable data in 1996. There are two exceptions noted in a comment at the bottom of Table 2 – the potato data are from 1997 and the strawberry data are from 1996.

Organophosphate active ingredients appear in "Bold" text, carbamates in "Italics." The first column reports each active ingredient's latest official Office of Pesticide Programs chronic Reference Dose. Exceptions are noted in the footnotes to the table. We assigned a "not less than 0.4 mg/kg" reference dose for chemicals that the EPA considers largely nontoxic. For such chemicals, EPA does not require as thorough toxicity testing and does not set a reference dose.

The values in Table 1 do not include any of the recently proposed changes in the 10-X safety factor, or Reference Doses as a result of ongoing toxicology evaluations triggered by the FQPA. While the EPA document "Hazard Assessment of the Organophosphates," dated July 7, 1998, suggests several changes in RfDs, these values are only the recommendation of one of many scientific committees assessing the need for changes in RfD values, and are not yet official.

The second column reports the "Number of Crop Uses" – the number of fruit and vegetable crops on which USDA reports acre treatments and pounds applied in 1996-1997. NASS chemical use surveys do not cover all acreage of each crop. No use is reported in cases where the reported "Percent Acres Treated" is less than 1 percent of total planted or bearing acres. According, data in this column marginally understate the number of crop uses.

"Acre Treatments" are reported in the third column – the number of acres of a given crop that were treated with one or more applications, multiplied by the average number of applications on those acres that were treated.

The last column reports "Pounds Applied" of each active ingredient on the 43 fruit and vegetable crops surveyed in 1996 and 1997.

Table 1. Insecticide Active Ingredients Applied to Fruits and Vegetables Ranked by Chronic Toxicity: Number of Crop Uses, Acre Treatments, and Pounds Applied in 1996-1997

Active Ingredient	OPP/EPA Chronic Reference Dose	Number of Crop Uses	Acre Treatments	Pounds Applied
Bold = Organophosphate; *Italics = Carbamate*				
Methyl Parathion+	0.00002	15	672,712	588,000
Terbufos	0.00005	2	15,607	21,300
Ethoprophos	0.0001	4	65,827	258,300
Fenamiphos	0.0001	6	87,725	141,700
Phosphamidon	0.0002	1	4,911	3,500
Oxamyl	0.0002	12	292,975	184,500
Mevinphos	0.00025	3	10,742	9,200
Chlorpyrifos+	0.0003	24	1,241,911	2,273,400
Disulfoton	0.0003	8	150,553	282,100
Abamectin	0.0004	15	898,003	9,021
Dimethoate+	0.0005	24	844,994	386,000
Ethion+	0.0005	6	170,447	431,300
Oxydemeton-methyl	0.0005	6	136,217	67,800
Phorate	0.0005	2	458,505	1,231,000
Diazinon+	0.0007	33	464,703	436,600
Methamidophos+	0.001	10	1,205,932	985,400
Aldicarb	0.001	3	147,125	429,300
Lambda-cyhalothrin	0.001	7	498,784	12,400
Acephate+	0.0012	9	326,365	256,100
Dicofol	0.0012	12	252,875	141,100
Azinphos-methyl+	0.0015	16	1,567,248	1,087,000
Methidathion+	0.0015	10	75,692	152,600
Fonofos	0.002	8	105,529	263,300
Naled	0.002	3	25,748	28,200
Formetanate HCL	0.002	5	81,225	76,100
Amitraz	0.0025	1	4,074	3,900
Phosmet+	0.003	10	296,273	444,900
Rotenone	0.004	4	27,732	236
Carbofuran	0.005	8	771,635	708,000
Methoxychlor	0.005	3	52,584	51,200
Tefluthrin	0.005	1	4,166	600
Endosulfan	0.006	23	857,843	671,300
Oxythioquinox	0.006	1	2,716	2,600
Cyromazine	0.0075	1	15,163	1,900
Methomyl	0.008	29	1,928,554	966,200
Cypermethrin	0.01	3	232,552	19,400
Zeta-cypermethrin	0.0125	4	166,220	7,446
Clofentezine	0.013	5	79,315	11,700
Carbaryl	0.014	33	696,222	954,700
Bifenthrin	0.015	3	65,063	5,400

Table 1. Continued

Piperonyl butoxide	0.0175	6	68,667	18,900
Tebufenozide	0.018	3	17,008	2,700
Diflubenzuron	0.02	5	40,594	15,300
Esfenvalerate	0.02	31	1,529,493	57,052
Cyfluthrin	0.025	2	189,127	18,000
Fenpropathrin	0.025	1	3,204	800
Hexythiazox	0.025	2	34,288	4,000
Thiodicarb	0.03	7	426,985	210,500
Malathion+	0.04	15	244,578	300,900
Propargite	0.04	9	384,322	658,400
Fenbutatin oxide	0.05	15	137,615	106,000
Permethrin	0.05	30	1,929,289	278,000
Imidacloprid	0.057	16	1,240,821	123,250
Pyrethrins	0.064	5	55,528	1,034
Fenoxycarb	0.08	1	23,154	2,900
Cryolite**	0.114	2	361,908	2,083,900
Sulfur	0.3	5	93,729	1,303,200
Bt *	0.4	31	1,629,395	16,293
Sabadilla *	0.4	4	99,275	2,400
Soaps *	0.4	2	16,430	53,300
Azadirachtin *	0.4	4	49,877	500
All Insecticides		565	23,527,875	18,861,532
OPs		215	8,172,218	9,648,600
Carbamates		98	4,367,874	3,532,200
OPs and Carbamates		313	12,540,092	13,180,800
OPs as a % of ALL		38%	35%	51%
Carbamates as a % of ALL		17%	19%	19%
OPs and Carbs as a % of ALL		55%	53%	70%

Notes: All RfDs used are OPP values as reported in the 2/19/97 "Reference Dose Tracking Report," except as noted below.

+ Reference Doses updated by EPA, December 1997.

* No RfD established because this insecticide is classified as "exempt from tolerance"; RfD value not less than 0.4 mg/kg.

** No RfD set; EPA instead uses the MCLG (Maximum Concentration Limit Goal) as determined under the Safe Drinking Water Act assessment of cryolite (see EPA document, Federal Register: March 12, 1997, Volume 62, Number 48, pages 11437-11441 [http://www.epa.gov/fedrgst/EPA-PEST/1997/March/Day-12/p6015.htm])

Table 2. Fruit and Vegetable Crops Surveyed for Chemical Use by the USDA in 1996 and 1997	
Fruits	**Vegetables**
Apples	Asparagus
Avocados	Lima Beans
Blackberries	Snap (Green) Beans
Blueberries	Broccoli
Dates	Cabbage
Grapefruit	Carrots
Grapes	Cauliflower
Kiwifruit	Celery
Lemons	Sweet Corn
Limes	Cucumbers
Nectarines	Eggplant
Olives	Head Lettuce
Peaches	Other Lettuce
Pears	Watermelon
Plums	Other Melons
Prunes	Onions
Raspberries	Potatoes*
Strawberries*	Processing Peas
Sweet Cherries	Bell Peppers
Tangerines	Spinach
Tart Cherries	Tomatoes
Temples	

* Potatoes were surveyed most recently in the 1997 field crop chemical use survey. Data on other vegetables were collected most recently in 1996. USDA classifies strawberries as a vegetable for purposes of collecting chemical use data. Strawberry pesticide use data is for 1996.