Toxic Tradeoff

Exit Diazinon, Enter Carbaryl

Phaseout Leads to Risky Replacement

by
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Executive Summary

The U.S. Environmental Protection Agency (EPA) is charged with protecting people, fish, and wildlife from harmful pesticides. The case of carbaryl, described in this report, proves that EPA is failing to fulfill this duty and is allowing this toxic insecticide to pollute our water and threaten the health of people and wildlife.

Carbaryl is a widely used insecticide that is toxic to the nervous system and may impair the immune system and cause cancer. It can cause harm to fish and the insects they rely on for food, and it poses a threat to bees and other wildlife.

To begin measuring the threat posed by carbaryl, the Clean Water for Salmon Campaign conducted a new analysis of past and current sales and water pollution data in the Northwest, and examined carbaryl toxicity. The analysis found an alarming trend toward greater contamination of several urban streams with carbaryl, together with greatly increased sales or use in some urban areas. These shifts coincide with a period when EPA phased out two insecticides. These results indicate that in the Pacific Northwest carbaryl may have replaced the popular insecticides Dursban™ (chlorpyrifos) and diazinon as the product of choice for treating lawn insects. They also indicate that carbaryl is replacing these pesticides as a primary concern for water quality and salmon.

Key Findings

Our analysis found the following:

1. Carbaryl threatens the health of people as well as fish and wildlife. Carbaryl poses a threat to human health by causing harm to the nervous system and may cause cancer. It is likely to harm salmon through a variety of means including effects on the nervous system, behavior, reproduction, and reduction of food supply.

2. Carbaryl use has increased greatly in urban areas. In King County, carbaryl purchases for residential use rose more than tenfold between 2001 and 2002. At the same time diazinon purchases dropped by a factor of two.

3. Carbaryl is a growing threat to water quality and salmon. Carbaryl levels measured in Seattle's Thornton Creek have risen at the same time that sales have increased. A similar increase in carbaryl was seen in the Portland area's Fanno Creek, indicating that carbaryl is likely to become one of our most significant contaminants of rivers and streams.

4. The Environmental Protection Agency has not adequately addressed the threat of carbaryl. The Environmental Protection Agency (EPA) has repeatedly failed to adequately evaluate and address the harmful effects of carbaryl on salmon and other endangered species as well as on human health.

Recommendations

Because of federal legislation and court orders, EPA is currently undergoing a process of evaluating the impacts of carbaryl on people, fish, and wildlife, and determining whether to ban or restrict its use. All indications are that EPA actions will be vastly insufficient to address the threat posed by carbaryl. Rather than dragging its feet on carbaryl, EPA should use it as a model for adequately assessing and addressing the human and ecological effects of pesticides.

EPA should do the following:

1. Thoroughly evaluate the ecological effects of carbaryl products and other pesticides. EPA must reissue its risk assessment and effects determination of carbaryl. Its analysis must include a thorough consideration of the implications of rising urban use of carbaryl. EPA must also evaluate factors such as the impact of exposure to multiple chemicals, reduction of salmon food sources, harm to the immune system and other sublethal effects, and toxicity of "inert" ingredients.

2. Consult with NOAA Fisheries on all potentially harmful uses of carbaryl. In its first analysis of carbaryl's harm to salmon, EPA ignored critical risk factors including its urban use. By ignoring these risks, EPA determined that carbaryl use in a number of areas, including Puget Sound, was insufficient to harm salmon. Once EPA revises its effects determination, it must engage in a full consultation with NOAA Fisheries for carbaryl effects in Puget Sound and other areas where there is potential for harm.

3. Eliminate uses of carbaryl that threaten salmon and human health. A ban on all carbaryl uses is the best way to ensure that this potent poison gets out of our streams, food, and homes. EPA must expedite the consultation process and respond to the fifteen public health, farmworker, beekeeping, and environmental organizations who recently called upon EPA to cancel all uses of carbaryl.

4. Stop this toxic tradeoff by supporting development of alternatives to carbaryl and other pesticides. Alternatives to carbaryl for lawn care are well-established, and EPA can play a role in encouraging their use. EPA can also support research on alternatives to carbaryl and other pesticides in agriculture.

EPA has failed to meet the challenge of protecting salmon and other endangered species from pesticides. We present a strong case that EPA should reform its system for considering and acting on impacts to endangered species. We expect EPA to act on this information and take bold steps to protect water and salmon from carbaryl and other pesticides.

Chapter 1:
Introduction to Carbaryl

When the U.S. Environmental Protection Agency acted to protect children's health by phasing out urban uses of the insecticides diazinon and chlorpyrifos (Dursban™), it also took a step toward addressing the major threat pesticides pose to salmon and steelhead in Northwest rivers. These two pesticides, particularly diazinon, have a tendency to stray from where they are applied and to migrate to rivers and streams, harming salmon and devastating their food supply (PANNA, EXTOXNET). Diazinon and chlorpyrifos are neurotoxic chemicals that harm not only their intended targets, but can kill or otherwise harm fish, and even at low levels can impact populations of invertebrates that fish depend on for food (PANNA, Cox 2000).

Children are exposed to pesticides when they play on lawns that have been treated. Their small body size and developing organs make them more susceptible than adults.

Unfortunately, EPA's strong action on these two pesticides is not the end of the story. Because EPA has no systematic means of ensuring that pesticides that harm fish and wildlife are restricted or phased out, many chemicals remain on the shelves today that contaminate our rivers and streams and pose a threat to salmon and steelhead.

A prime example is the insecticide carbaryl, which is currently undergoing review by EPA. Like chlorpyrifos and diazinon, it is neurotoxic, exerting harmful effects not only on pest insects but on people, fish, and wildlife. And like diazinon, carbaryl moves from lawn or field to stream.[1]

Carbaryl (most common trade name Sevin™) is a broad-spectrum insecticide, meaning that it affects a wide range of species. Because of its nonselective action, carbaryl is used to control over 100 species of insects on fruit and other trees, cotton, lawns, ornamentals, and other crops, as well as on poultry, livestock, and pets (EXTOXNET). It is one of the most widely used insecticides by homeowners as

[1] The Groundwater Ubiquity Score (Vogue 1994) indicates that carbaryl and diazinon are about equal in their mobility in soil. The Surface Water Mobility Index (Chen 2002) predicts that carbaryl is more likely than diazinon to run off of treated landscapes.

well as professionals in landscaping and nurseries, and is commonly used in agriculture (USEPA 2001, WSDA 2004). Carbaryl is a carbamate insecticide that affects the nervous system by inhibiting the enzyme acetylcholinesterase, allowing a buildup of a key neurotransmitter at the nerve endings and thereby disrupting nervous system function (Schettler 2000). Carbaryl's neurotoxicity makes it an effective insecticide, since many species share basic nervous system structure. However, it also makes carbaryl a potent poison for people as well as fish and wildlife.

Carbaryl is sold to consumers for general lawn and garden use as both a liquid and in granular form. Generally, these products are sold as controls for various insects, especially caterpillars, soil-dwelling insects, and grubs. Carbaryl is also available for treating pets and pet sleeping areas. Additionally, carbaryl is sold in a two-for-one formulation with a slug killer, creating a product known as a "slug and bug" bait.

Chapter 2:

Federal Regulation of Carbaryl

Carbaryl was first registered, or approved for use, in 1959 (USEPA 2003a). At that time, there were no protections in place to ensure that pesticides did not harm people or fish and wildlife. Beginning in 1972, Congress has increased health and environmental protections, but continued use of pesticides is allowed while EPA reconsiders them according to newer standards. Shockingly, carbaryl has never been brought into compliance with current standards.

Carbaryl is now undergoing "reregistration," the process under the Federal Insecticide, Fungicide, and Rodenticide Act in which EPA assesses a pesticide with current regulatory standards. As part of the process, EPA completes risk assessments on human and ecological impacts and takes public comment on those assessments and on potential restrictions.

EPA has indicated (USEPA 2003a) that it is likely to make some limited changes in carbaryl use, including:

• eliminating residential lawn care liquid broadcast applications;
• limiting liquid residential lawn care products to pint-sized ready-to-use hose-end sprayers, for spot treatment use only;
• restricting dust products for home and garden to ready-to-use shaker can containers, with no more than 5 lbs. active ingredient per container; and
• eliminating all pet uses (dusts and liquids) except collars.

EPA has not proposed any major changes in agricultural uses and is not planning to eliminate granular applications for lawns, a use that has strong potential to be problematic both for people and fish in the Northwest based on the information in this report. Thus, these changes are unlikely to result in a significant improvement in water pollution. However, EPA has received very strong public comment during this reregistration process calling for stricter controls on carbaryl. In January 2005, fifteen public health, farmworker, beekeeping, and environmental groups called upon EPA to end all uses of carbaryl because of unacceptable impacts on human and ecoystem health including on pollinators such as honeybees.

The U.S. Fish and Wildlife Service, also commenting on EPA's proposed steps, has indicated concern that EPA's changes will not significantly affect use. In its comment letter, the Service stated, "Despite the risk to nontarget organisms described . . . the IRED [reregistration document] proposed only the slightest measures to alleviate potential ecological effects . . ." Furthermore, the letter states, "Mitigation measures that were designed to address occupational and residential risk (cancellation or reduction of application rates for 16% of the uses) reduce ecological risk to some degree, but account for less than 25% of the actual pesticide volume applied annually." (USFWS 2005)

Protections for Endangered Species

Under the mandates of the federal Endangered Species Act, EPA is also engaged in a "consultation" with the National Marine Fisheries Service (NOAA Fisheries) to assess and safeguard against the adverse effects of carbaryl and other pesticides on salmon. In the consultation process, EPA conducts a preliminary analysis called an "effects determination." NOAA Fisheries must then decide whether the current pesticide uses jeopardize salmon survival. If they do, NOAA Fisheries will establish "reasonable and prudent alternatives" needed to avoid the jeopardy. NOAA Fisheries will also determine whether the pesticide use will harm salmon and may impose mandatory terms and conditions to minimize that harm (USFWS and NOAA Fisheries 1998).

EPA has a shameful history when it comes to consultations on pesticides. The agency consulted with the U.S. Fish and Wildlife Service in the 1980s on a number of pesticides, but the reasonable and prudent measures established by Fish and Wildlife were never implemented. More recently, EPA was ordered in July 2002 to initiate consultations on the effects of 54 pesticides on salmon (Washington Toxics Coalition et al. v. EPA 2002). EPA completed the last of the 54 effects determinations, which are the first step in an ESA consultation, according to the court-ordered timeline in December 2004. However, not one of the consultations has been completed, and there is no indication when they will be completed and produce the sorely needed on-the-ground protections.

Moreover, EPA has persisted in using a highly simplified and unreliable method to judge the effects of pesticides on salmon and other species. EPA bases its determinations almost entirely on lethal impacts: that is, how much of the pesticide is needed to kill the plant or animal (USEPA 2003b). Despite years of accumulated evidence that more subtle, or sublethal, effects can have major impacts on the survival of populations, EPA has refused to update its methods to account for these impacts, which range from behavioral and immune effects to carcinogenicity. Neither does the agency account for additive effects from multiple pesticides, or even the effects of the full product: tests are conducted one pesticide at a time and only on the "active" ingredient, which often makes up a small percentage of the product.

In an attempt to avoid conducting full consultations with fish and wildlife agencies on the impacts of pesticides, EPA worked with these agencies to change the rules of consultation. In

Photo by Steve Maslowski, courtesy of the U.S. Fish and Wildlife Service

EPA's highly simplified and unrealistic methods do not adequately protect birds, salmon, and other threatened or endangered species.

order to win the support of the fish and wildlife agencies, EPA has pledged to make some changes in its procedures and to make more in the future (USFWS and NOAA Fisheries 2004, USEPA 2004). In fact, EPA has now indicated its intention to redo all effects determinations for salmon in which it had determined that the pesticide may affect salmon but was not likely to do so. Its second attempt to characterize how carbaryl may harm salmon will be a good test of whether it is taking its pledge of improvement seriously and whether it truly intends to protect salmon and other endangered species. Public interest groups will be monitoring, in particular, EPA's determination on the likely effects of carbaryl on salmon in the Puget Sound area. EPA's previous determination was that carbaryl was not likely to affect salmon, which under current rules means that EPA does not consult with NOAA Fisheries.

http://research.nwfsc.noaa.gov/cbd/trt/

Yellow shading indicates the areas where threatened and endangered Pacific salmon and steelhead are present. In the Puget Sound area, Chinook are listed as threatened, but EPA has failed to adequately consider and prevent the harm carbaryl may cause Puget Sound Chinook.

Why Harmful Pesticides are Still Used

An extensive regulatory system in the United States considers pesticide threats to people, fish, and wildlife. So why are there pesticides in current use that EPA considers likely to cause cancer, that have known toxicity to the nervous system, and that harm reproduction? There are several reasons.

Pesticide law does not require safety. The federal pesticide law, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), makes no guarantee that pesticides allowed for use will not cause harm to people and other living things. Rather, the law establishes a risk/benefit standard: it requires a pesticide to be allowed unless it poses "unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide." Thus, as long as the economic benefits outweigh expected risks to health, the pesticide is allowed for use. The Food Quality Protection Act of 1996 did improve this standard somewhat for pesticides used on food, but many of its provisions have not been implemented. Under either standard, EPA assesses harm using a risk assessment method that does not fully account for exposures and vulnerabilities.

EPA's testing requirements are insufficient. Testing for long-term effects is conducted only on the active ingredient, rather than on the product as sold and used. Thus, the toxicity of "inert" ingredients, which often make up most of the product, is largely not considered. In addition, EPA does not generally require testing for important effects such as hormone disruption and developmental neurotoxicity. Finally, many "required" tests are often waived and data gaps often remain for years.

Many pesticides have not been evaluated under today's standards. In 1972, Congress passed amendments to FIFRA requiring evaluation for health and environmental effects. More than thirty years later, EPA is still in the process of evaluating pesticides for these effects, in a process known as reregistration. Lack of resources and political pressure have combined to create an ongoing backlog for consideration of pesticide toxicity.

The fact that carbaryl is still used today, despite the knowledge that it is considered likely to cause cancer and is known to cause nervous system harm in people and wildlife, illustrates the failure of EPA's risk calculations to fully protect us, and the Agency's inability and unwillingness to eliminate all harmful pesticide uses. At their essence, federal pesticide laws do not prevent pesticides that are carcinogens, neurotoxic, or toxic to the reproductive system from being produced and marketed.

Europe has embarked on creating regulations that for the first time on a large scale are designed to prevent chemicals that are highly toxic from being produced and marketed. These regulations, known as REACH (for Registration, Evaluation and Authorization of Chemicals), would require that industry provide and make public data on the health and environmental effects of more than 30,000 high-volume chemicals. Where testing shows a chemical to be carcinogenic, toxic to the reproductive system or to development, or to disrupt hormonal systems, authorization would be required before production is allowed. Authorization would only occur if strict controls and proof of need could be demonstrated.

This regulatory system is a far cry from the U.S. system of risk/benefit analysis for pesticides. And in the United States, the situation is even worse for other kinds of chemicals. The vast majority of chemicals used in commerce have virtually no regulation, despite mountains of scientific evidence showing certain chemicals can cause devastating health problems.

There is no reason that a system such as REACH could not be implemented in the United States, and every reason to move toward this type of system. With rising rates of diseases from breast cancer (Evans 2004) to asthma (Mannino 1998, Gergen 1992), increasing rates of learning disabilities (Schettler 2000), and the growing awareness that each person is contaminated with a cocktail of toxic chemicals (Schafer 2004), there is no time to lose in eliminating use of the most-toxic chemicals, including pesticides. And finally, besides the paramount importance for health, U.S. companies will soon be at a competitive disadvantage worldwide if they do not move toward safer materials. It is clearly time to move toward a major overhaul of U.S. regulation of pesticides and other chemicals.

Chapter 3:

Carbaryl Threats to Human Health

People can be exposed to carbaryl when they are applying it, through contact with lawns and garden plants, by eating fruits and vegetables contaminated with carbaryl, and from drift. Carbaryl enters the body through ingestion, inhalation, eye contact, and skin absorption (EXTOXNET).

Carbaryl's primary effects are on the nervous system. Symptoms of acute overexposure to carbaryl include many nervous-system effects. Inhalation or ingestion of large amounts can result in nausea, stomach cramps, diarrhea, and excessive salivation. Other symptoms at high doses include sweating, blurring of vision, loss of coordination, and convulsions (USEPA 2003a).

EPA's most-recent risk assessments for carbaryl indicate several residential uses pose unacceptable risk (USEPA 2003a). These include garden dust application, hose-end sprayer, lawn care (broadcast use), hand application of baits, and most pet uses. Toddlers (3-5 years) would be exposed to unacceptable risk levels on lawns for 14-18 days after treatment.

Carbaryl has been strongly linked to cancer. EPA considers carbaryl to be a likely human carcinogen (USEPA 2003a). A number of studies have tracked disease among people exposed to carbaryl. Several studies have reported greater incidence of childhood brain cancer in homes using carbaryl (Davis 1993) or categories of products that may contain carbaryl (Pagoda 1997). Other studies have found an elevated risk of non-Hodgkins lymphoma (NHL) among farmers who handled carbamate insecticides in general and carbaryl in particular. A study of Canadian farmers (McDuffie 2001) reported that farmers using carbaryl had twice the incidence of NHL, with a slightly lower increased risk when all carbamates were considered together. A reanalysis (Zheng 2001) of pooled data from three separate studies in several Midwestern states found a 60% increase in NHL for farmers who reported using carbaryl. While these studies do not prove an association, they had large sample sizes and the findings correlate with experimental findings linking carbaryl to suppression of the immune system, which is a known risk factor for NHL (Zheng 2001).

Children playing on lawns treated with carbaryl are receiving unnecessary exposures to a substance EPA considers likely to cause cancer in humans.

Carbaryl may suppress the immune system. Laboratory studies have found that carbaryl is a particularly potent inhibitor of immune responses. Street and Sharma (1975) found that laboratory animals exposed to carbaryl at levels below those causing obvious toxicity significantly reduced antibody production. Other animal studies have found reduced proliferation of lymphocytes at levels that did not affect nervous system function (Casale 1993).

Carbaryl may be an endocrine disruptor. Carbaryl was listed as a suspect endocrine disruptor by Illinois EPA in 1997 (Illinois EPA 1997). In laboratory tests, carbaryl was found to mimic the hormones estrogen and progesterone. It also affected the response of breast cancer and endometrial cancer cells to these hormones (Klotz 1997).

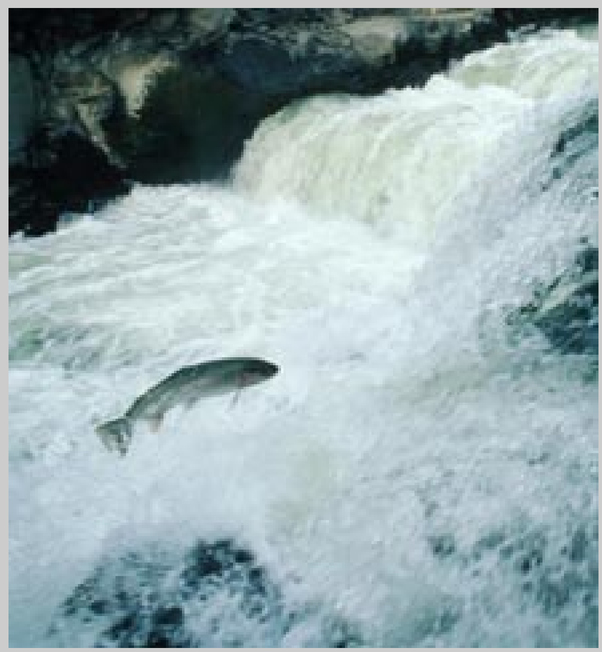
Chapter 4:
Carbaryl Pollution and its Impacts

Carbaryl can be both persistent in soil and water as well as mobile in runoff, so it is a common contaminant in streams, rivers, and lakes. Nationally, carbaryl is the second-most commonly detected insecticide, found in 21% of samples (USEPA 2003a). In many cases carbaryl has been detected at levels that exceed water quality benchmarks, meaning it is present at a level greater than considered safe for aquatic life.

The maximum observed concentration for carbaryl in surface water from the USGS National Ambient Water Quality Assessment (NAWQA) study, which does not target rainfall events, is 5.5 micrograms per liter (hereafter referred to as parts per billion, or ppb). However, a Washington State Department of Agriculture/ Department of Ecology study found carbaryl at 10 ppb in 2004 in an agricultural drainage (WSDA and WDOE 2004). Generally, USGS has found that streams draining urban areas show more frequent detections and higher concentrations than streams draining agricultural or mixed land-use areas. Most sampling is not designed to capture peak concentration levels, so actual maximum levels are likely to be higher than reported.

Carbaryl has been found at high frequencies in many Northwest watersheds:

- Carbaryl was detected in 100% of the samples from Arcade Creek, an urban watershed in the Sacramento basin, with a maximum of 2 ppb (Domagalski 2000);
- Carbaryl exceeded aquatic life guidelines in 17 of 46 detections in the Willamette basin, with both rural and urban areas (Wentz 1998);
- In the agricultural Yakima River basin, carbaryl was found in 75% of Yakima River samples and 100% of samples from the Granger Drainage Basin (Ebbert 2002); and
- During rainstorms, carbaryl was detected in about 70% of samples in King County streams in 1998 (Voss 2000)



Nationally, carbaryl is the second-most commonly detected insecticide in surface water. Streams draining urban areas show higher levels of carbaryl than streams in agricultural or mixed-use areas.

There is very strong evidence in the literature that carbaryl can have effects that are likely to significantly reduce fish populations, including salmon. Carbaryl can harm fish through the following means:

Carbaryl severely impacts the fish nervous system. Carbaryl alters neurotransmitter levels in fish, causing impacts including hyperactivity, overreaction to stimuli, loss of equilibrium, altered locomotion, increased respiration, and death (Ferrari 2004). It does so by inhibiting acetylcholinesterase function. Effects including reduced swimming speed have been seen in field studies as well as laboratory studies (Davis 2004). Extremely disturbing are studies that show that carbamates and organophosphate pesticides (such as diazinon and chlorpyrifos) have a synergistic effect in inhibiting acetylcholinesterase, meaning that these chemicals have an even greater effect in combination than would be expected by adding their effects (Bocquene 1995).

Fish exposed to carbaryl experience metabolic and organ damage. Carbaryl has been shown to alter carbohydrate metabolism and affect the liver, with the effect increasing with duration of exposure (Jyothi 1999). Concentrations as low as 1 ppb have been shown to reduce the protein and lipid contents of fish muscle, liver, and gonad tissues (Kaur 1996).

Significant reproductive effects have been found in fish. In laboratory studies, carbaryl significantly reduces the ability of fish to reproduce, decreasing fertilization rate as well as size, hatchability and survivability of eggs (Kaur 1996). Carbaryl can also delay hatching, increasing susceptibility to predation (Todd 2002). Finally, carbaryl impairs reproduction by reducing levels of controlling hormones (Ghosh 1990).

Carbaryl alters fish hormonal and immune systems. Carbaryl has been shown to modify levels of thyroid hormones (Sinha 1991). Carbaryl at 0.1 ppm in aquatic environments led to atrophy of lymphoid organs and depletion of lymphocytes in salmonids after 100 days of exposure, increasing susceptibility to parasites (Dunier 1993).

Effects on fish behavior can have far-reaching implications. Besides the severe neurological effects at higher concentrations, sublethal concentrations have been shown to affect behaviors such as the startle response (Carlson 1998). Carbaryl also reduces swimming speed, which can affect a population by limiting feeding and impairing the ability to avoid predators, migrate, and attract mates (Beauvais 2001); it has also been shown directly to increase vulnerability to predators (Little 1990).

Carbaryl can disrupt food supply. Carbaryl can affect salmon by diminishing populations of the aquatic invertebrates that make up a major portion of their food supply. EPA considers carbaryl very highly toxic to aquatic invertebrates. Further, in its most-recent risk assessment, EPA determined that likely concentrations in water would exceed its acceptable risk level by factors of from 4.5 to 55 (USEPA 2003a).

There is evidence that levels of contamination that already have been detected in streams can impact fish populations. For example, Kaur (1996) found effects on reproduction at 2 ppb, a level that has been detected in surface water sampling as noted earlier. In addition, a field study (Gruber 1998) found a 34% reduction in acetylcholinesterase, reflecting nervous system harm, in a lake that received irrigation return flows as compared to a lake outside of the irrigation system. While carbaryl was not the only insecticide present, it was among the five most frequently detected, and this study suggests that combined effects of cholinesterase-inhibiting insecticides may be very significant in the environment.

Chapter 5:

Carbaryl's Urban Use and Sales, and a Close Look at Two Urban Streams

Liquid lawn applications of carbaryl may be stopped in the near future, but granular applications will continue. Use of granular carbaryl products has increased sharply in King County, according to data presented in this report.

Since the passage of the Food Quality Protection Act in 1996, which required EPA to consider both children's extra sensitivity and multiple exposures to pesticides, allowed uses of some insecticides have changed dramatically. Two of the most commonly used insecticides nationally, diazinon and chlorpyrifos, have recently been phased out for home and garden use. Both of these chemicals are broad-spectrum insecticides used for many purposes indoors, outdoors, in urban areas and in agriculture, and their restriction has led the pesticide industry to seek replacement chemicals.

Carbaryl has emerged as the insecticide of choice for many applications, and some manufacturers are actively marketing it as a replacement for diazinon. A promotional package that was mailed to county extension agents and Master Gardeners around the country in 2004 stated "Sevin® is the best replacement for diazinon and Dursban® users" and announced a new granular formulation for homeowners to use on the lawn. The package included a mail-back postcard that could be redeemed for a free 10-pound sample bag of carbaryl lawn insect granules "to test on your lawn or use in field trials." (GardenTech 2004)

Available sales and use data for the last several years indicate a sharp increase in use, particularly in some urban areas. The pesticide use reports submitted to the California Department of Pesticide Regulation show that for the most common urban use of carbaryl - for landscape management - carbaryl use has increased by almost 40%, from 10,096 pounds of active ingredient in 2000 to 13,937 pounds in 2003 (CDPR). In the same time period, carbaryl use for structural pest control more than doubled from 2,441 pounds of active ingredient in 2000 to 8,812 pounds in 2003. These data reflect only use by professionals because consumer data are not collected by California.

Concerned that carbaryl use in the Northwest might be following a similar pattern, the Washington Toxics Coalition undertook an analysis of changes in carbaryl usage and pollution after the phaseout of diazinon and chlorpyrifos. We focused our analysis on diazinon and carbaryl because chlorpyrifos was infrequently detected in surface waters in the study area. We compiled available insecticide sales data and compared them to the extensive pesticide sampling data on urban streams developed by the U.S. Geological Survey. We selected Thornton Creek in Seattle and Fanno Creek in Portland as the most appropriate watersheds to look for changes in water quality. The bulk of the results presented below are excerpted from a manuscript currently in preparation (Dickey and Wilson 2005).

Retail Insecticide Sales

We examined data on sales of insecticides at two "big box" hardware/home improvement store chains within King County between 1997 and 2002. Reports were purchased from CCI Triad (Vista 1998-2003) by King County Department of Natural Resources' office of the Local Hazardous Waste Management Program. Monthly data for 1997 through 2002 include sales from up to 17 stores. Pounds of active ingredient for each product were computed from the percent active ingredient and package size.

As seen in Figure 1, the annual retail sales for diazinon and carbaryl were relatively constant between 1997 and 2001, with sales of diazinon more than ten times higher than sales of carbaryl. In 2002, however, the situation changed, with diazinon sales dropping by about a factor of two and carbaryl sales jumping more than tenfold. Retail sales of both chlorpyrifos (not shown) and diazinon began to decrease substantially well before their final phaseout dates, while carbaryl sales showed the largest increase and highest sales of any insecticide in 2002. (Other insecticides, especially synthetic pyrethroids such as permethrin and bifenthrin, have also shown strong increases in sales. They were not included in this analysis because water quality data were not available.)

The timing of carbaryl sales also changed noticeably in 2002, acquiring a secondary peak in late summer that had been associated in the past with diazinon but not carbaryl. This change in monthly pattern of carbaryl sales in 2002 gives an indication of how carbaryl is starting to be used and how it may be used in the future. The double peak in seasonal diazinon sales likely results from its major use to control crane flies. Homeowners and landscapers primarily treat for crane flies in the spring, when grubs are in the soil. However, it is likely that they also treat to a lesser extent in the late summer and fall, when adult crane flies are flying and often seen by consumers, sometimes inside the home. In 2002, when carbaryl sales surpassed those of diazinon, the carbaryl sales peak broadened out and acquired the late summer/early fall secondary peak characteristic of diazinon sales.

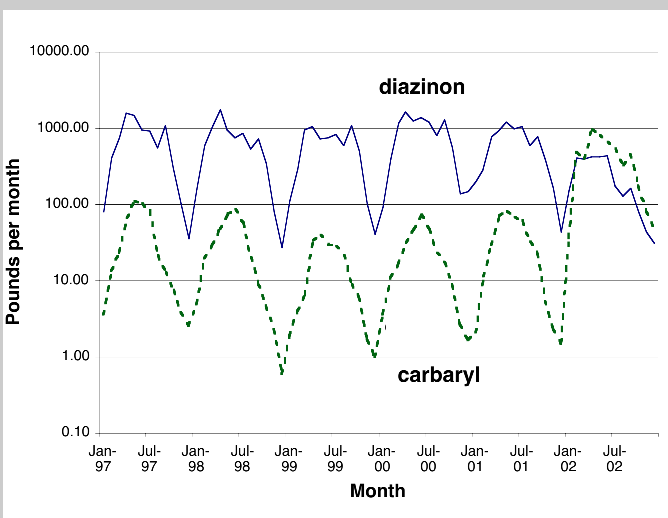


Figure 1. Monthly Sales of Diazinon (solid line) and Carbaryl (dashed line) in pounds of active ingredient. Sales are reported for large hardware/home improvement stores in King County, Washington.

We also found that in 2002 virtually all of the increase in carbaryl sales came from the granular product used on lawns. Prior to that time, most carbaryl sales were in combination slug/insect baits for garden use and liquid formulations, with granular and dust products making up the smallest proportion. It appears that carbaryl has become a chemical replacement for the lawn uses of diazinon and chlorpyrifos in the Northwest.[2] Thus, carbaryl can be expected to be an increasingly significant contaminant in urban and mixed-use areas, particularly in the Pacific Northwest where it is used extensively on turf for crane fly control.

Non-consumer use of pesticides also contributes to runoff in the watershed. Our retail sales analysis does not account for pesticide use by professionals, but the phaseout of diazinon and chlorpyrifos for urban uses also applies to these applicators, so a switch to alternative insecticides including carbaryl is expected to have occurred for this group as well and would contribute to the overall trends observed.

Cconclusion: Carbaryl sales in King County increased more than tenfold in 2002, due mainly to purchases for lawn applications. Diazinon sales fell by half.

Insecticides in Streams

Pesticide-sampling data were downloaded from the publicly available United States Geological Survey (USGS) National Water Information System (NWIS) and National Water Quality Assessment (NAWQA) Data Warehouse.. The sampling and analysis methods used by USGS have been described in detail elsewhere (Embrey 2003, Voss 2000). Two urban creeks with the most complete sampling data were selected, Fanno Creek in the Portland, Oregon metropolitan area and Thornton Creek in Seattle, Washington. We analyzed reported concentrations of diazinon and carbaryl between 1993 and 2003, a period that encompasses the phaseout timeline for diazinon. Statistical analyses were performed on Thornton Creek data to confirm the significance of apparent changes.

During the time spanned by this data set, the USGS increased the reported detection limits (called reporting limits) for both diazinon and carbaryl in order to minimize false positive detections. Since it is not appropriate to compare data reported with different detection limits, we analyzed as detects only data points above the higher (more recent) reporting limits for each chemical.

Thornton Creek

While data are available for many watersheds within King County, Thornton Creek has seen the most consistent sampling over the time period of interest: 1996-2002. The sampling includes measurements taken during both storm- and base-flow conditions in each year. Unfortunately, no measurements were made during 1999 and 2000, leaving a gap in the middle of the data set, but it was still possible to compare insecticide concentrations before the EPA announcement of the diazinon phaseout with two years of data following the announcement.

[2] This conclusion assumes that sales observed in the two large store chains are representative of sales in the region and that the changes observed in 2002 were not an aberration. Unfortunately, data to confirm these facts are unavailable. In addition, while product sales may differ from product use, averaged over many households we expect them to show similar trends. The correlation observed between sales and stream concentrations of carbaryl and diazinon suggests that the limited sales data are at least qualitatively predictive of product use in the watershed.

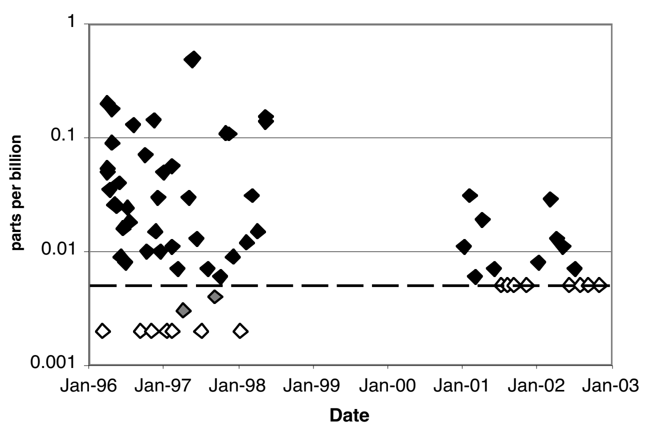


Figure 2. Diazinon concentrations (parts per billion) for all samples from Thornton Creek. Data points represent detections (solid), estimated detections (shaded), and non-detects (open) shown at reported detection limit. Dashed line indicates current reporting limit.

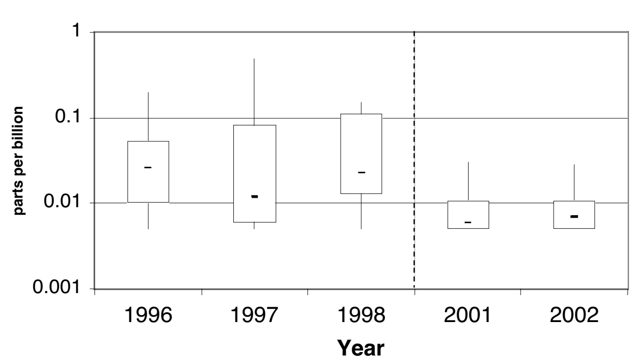


Figure 3. Box plot of diazinon concentrations reported in Thornton Creek by year. Graph shows high and low values (whiskers), 25th and 75th percentile values (boxes), and median values (hash marks).

Thornton Creek drains a primarily urban area of 12.1 square miles within the City of Seattle (Embrey 2003) housing about 75,400 people in 33,362 households. Land use in the watershed is 51% residential, 23% rights-of-way (roads and shoulders), 8% commercial, 4% parks, 4% schools, 4% vacant, and 3% other. The high residential land use in the watershed makes Thornton Creek a reasonable place to look for landscape pesticides used on lawns.

Diazinon

Figure 2 shows the diazinon concentrations reported for all samples collected from Thornton Creek during 1996 through 2002. No data were available for the years 1999 and 2000. In this graph, each horizontal line represents a tenfold change in concentration. The dashed line shows the current reporting limit. There appears to be a decrease in concentrations from the earlier time period (1996 to 1998) to the later time period (2001 and 2002). The decrease is even clearer in Figure 3, which groups the measurements by year and plots medians and percentiles.

Statistical analyses were performed to determine whether the apparent decrease is statistically significant. The Mann-Whitney test was chosen because the results do not depend on arbitrary assumptions for non-detects, such as setting them to zero or one-half the detection limit. Data points were ranked by concentration from low to high, and the Mann-Whitney test (SPSS version 10.1.0) was employed on the ranks to test whether or not pesticide concentrations changed from year to year. These tests indicated that diazinon levels did decrease significantly and that it is more likely that the change occurred in 2001 ($p=0.002$) than in 2002 ($p=0.038$). The Mann-Whitney test does not measure the magnitude of the decline in diazinon concentrations, but a comparison of the calculated median concentrations shows that the median in 2001-2002 declined by a factor of 3.2 compared to the 1996-1998 period.

Conclusion: Diazinon concentrations in Thornton Creek were significantly lower in 2001 and 2002 compared to 1996-1998.

Carbaryl

The carbaryl data for Thornton Creek are shown in Figure 4. Despite the very small number of detections, carbaryl concentrations appear to have increased. Before 1999, only one detection (0.044 ppb) slightly exceeded the current reporting limit (0.041 ppb), and four others were well below it. In 2001, again only one detection (0.072 ppb) was over the reporting limit and two others were below. In 2002, however, four detections can be seen: three in the spring (0.054, 0.064, and 0.483 ppb) and one in the fall (0.219 ppb). In 2002, then, we have the most carbaryl detections as well as the two highest carbaryl concentrations measured in the five years of sampling in Thornton Creek.

The Mann-Whitney test indicated that there was a statistically significant increase in carbaryl concentrations between the period 1996-1998 and 2001-2002 ($p = 0.001$). When the year 2001 was grouped with the 1996-1998 data and tested against 2002 alone, a significant increase was again found, but with a lower P value ($p < 0.001$) suggesting that it is more likely the change occurred in 2002. Due to the small number of detections, the increase in carbaryl concentrations could not be quantified.[3]

Conclusion: Carbaryl concentrations were significantly greater in Thornton Creek in 2001 and 2002 as compared to 1996-1998.

[3] The data analysis for carbaryl was limited by two factors. First, all measured carbaryl concentrations (except where reported as below detection limit) are reported by USGS with the remark code "E" which indicates a positive detection but an estimated concentration. Second, the censoring of the data needed because of the change in detection limits resulted in very few carbaryl detections. The scarcity of valid detections did not prevent determining the statistical significance of any change, but it did preclude determining the magnitude of the change.

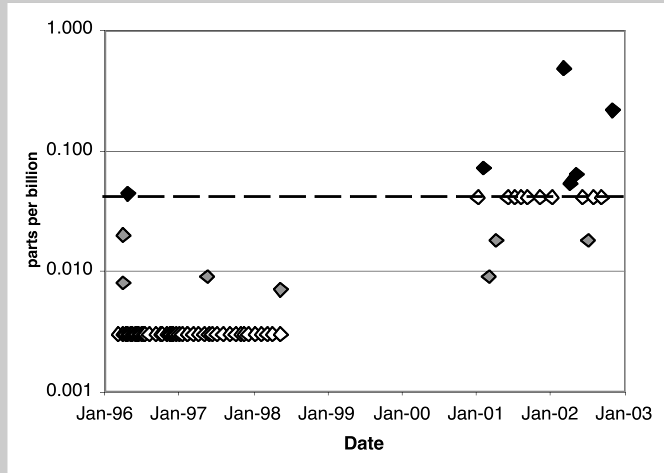


Figure 4. Carbaryl concentrations for all samples from Thornton Creek. Data points represent detections (solid), detections below current reporting limit (shaded), and reported non-detects (open) shown at reported detection limits. Dashed line indicates current reporting limit.

Fanno Creek

Similar increases in carbaryl pollution have also been seen in an urban stream near Portland, Oregon. Fanno Creek runs though the urban/residential areas of Beaverton and Tigard before flowing into the Tualatin River near Durham, south of Portland. The 35-square-mile watershed is considered urban, and includes industrial areas, commercial complexes, and residential neighborhoods. Figures 5 and 6 shows measured concentrations of diazinon and carbaryl, respectively, in Fanno Creek.

The data available for Fanno Creek are in two blocks: 1993-1995 and 2001-2003. A large decrease in diazinon and an increase in carbaryl concentrations can clearly be seen recently as compared to the earlier period.

Diazinon

From 1993-1995, 97% of samples had diazinon concentrations that exceeded the current reporting limit. The

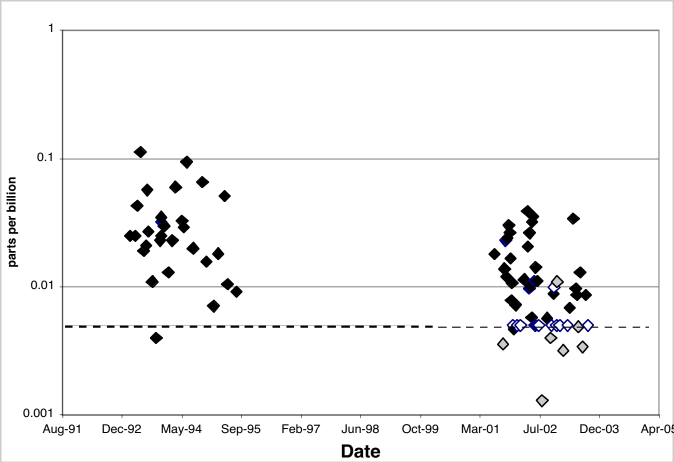


Figure 5. Measured diazinon concentrations (ppb) in Fanno Creek, near Portland, Oregon. Dashed line indicates current reporting limit.

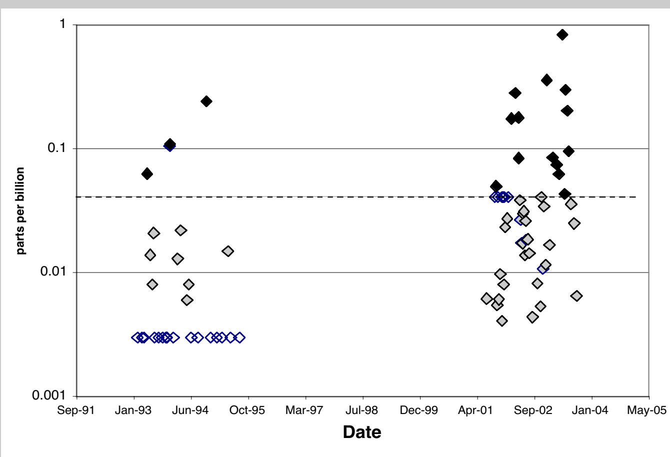


Figure 6. Measured carbaryl concentrations (ppb) in Fanno Creek, near Portland, Oregon. Dashed line indicates current reporting limit.

maximum observed concentration was 0.112 ppb and the median concentration was 0.025 ppb. From 2001-2003, however, only 64% of samples exceeded the current reporting limit, and the maximum concentration was much lower, at 0.09 ppb. The median concentration was .0093 ppb. From the earlier to the later period, the median concentration decreased by more than a factor of two. (See Figure 5.)

Carbaryl

From 1993-1995, only 15% of samples had concentrations exceeding the current detection limit of 0.041 ppb (shown as a dashed line). The highest reported concentration was 0.242 ppb. From 2001-2003, however, 30% of samples exceeded the detection limit. The highest concentration measured was 0.842 ppb, and three other samples exceed the highest concentration seen previously. (See Figure 6.)

Conclusion: Carbaryl levels increased in Fanno Creek in 2001-2003 as compared to detections from 1993-1995. At the same time, diazinon concentrations decreased substantially.

Data from other regions of the country have generally not shown the same increases in carbaryl concentrations in urban streams, and indeed many show decreases. One possible explanation is that differing pest control needs in other geographic areas may lead residents to make different substitutions for diazinon and chlorpyrifos, such as pyrethroids for example. Pyrethroids are more likely to be detected in sediment than in the water column because of their chemical/physical properties. Therefore, the Pacific Northwest may be rather unique in the extent to which carbaryl use is increasing. Even if it is not seen elsewhere, this increase in carbaryl levels in urban Northwest streams is important because of its implications for endangered salmonid habitat.

At the same time, studies in other parts of the country have found relatively frequent detections of carbaryl. For example, levels up to 1.5 ppb have been detected in the last several years in the Norwalk River, Connecticut; there have been a number of detections up to 0.75 ppb at Caswell State Park, California; and USGS has found multiple detections of carbaryl up to 0.39 ppb in Little Buck Creek, Indianapolis (USGS 2005). Thus, even where levels are not increasing, carbaryl contamination remains a water quality problem.

Carbaryl as Primary Pollutant

From these results we conclude that diazinon concentrations in Thornton and Fanno Creeks have decreased following EPA's 2000 announcement of the phase-out of residential uses and well before the final year of sales in 2004. This decrease roughly coincided with a large drop in retail sales in 2002. Carbaryl sales and stream concentrations have followed the opposite pattern. Sales in King County climbed more than tenfold in 2002, driven by granular carbaryl formulations most likely used for crane fly control on lawns. At the same time, carbaryl concentrations in Thornton and Fanno Creeks increased substantially, with more detections and higher concentrations than previously seen. Because the changes observed for the two insecticides are in opposite directions, they cannot both be caused by confounding factors such as incomplete retail reporting or variations in stream flow, which would affect both chemicals in the same way.

As stated earlier, carbaryl's history is as a significant pollutant, particularly in urban streams, but secondary to diazinon. The Thornton Creek sampling data clearly show the effect of regulatory action on diazinon sales and stream concentrations, and together with the Fanno Creek data they provide the first glimpse of how increasing carbaryl use is causing stream concentrations to rise. In coming years, it is likely that carbaryl will become one of the most problematic chemicals polluting salmon streams. And while EPA has indicated its intention to make some changes in residential uses of carbaryl, it is not phasing out the turf uses that account for the large rise in carbaryl use in the Northwest.

Conclusion: Pesticide sales and water pollution data strongly suggest that carbaryl is emerging as a major replacement for diazinon and chlorpyrifos in Northwest urban areas.

Chapter 6:

How EPA Must Change its Actions to Address the Threat of Carbaryl

The Environmental Protection Agency (EPA) is charged under national pesticide laws and the Endangered Species Act with protecting people, fish, and wildlife from pesticides, and ensuring that pesticides do not harm endangered species. The case of carbaryl illustrates EPA's broad failure to fulfill this mission.

EPA routinely fails to consider the true impacts of pesticides on salmon and other endangered species.

1. EPA's analysis is outdated and based almost entirely on lethal impacts. EPA's risk assessment process for fish and wildlife makes the flawed assumption that tests determining the amount of the pesticide needed to kill animals can be used to predict more subtle, sublethal impacts. In the case of carbaryl, EPA's analysis takes a brief look at the literature on reproductive and hormonal impacts, but does not do a full literature review or require additional studies. Rather, EPA quickly dismisses the literature in favor of its 1979 "6x hypothesis," which asserts that sublethal effects will not occur at levels below one-sixth of the lethal level based on a review of the 1970s literature. EPA concludes in its effects determination that "it would be premature to abandon the hypothesis for other sublethal effects until there are additional data." (USEPA 2003b) EPA makes this conclusion despite its admission that "[i]t would appear that the Scholz et al (2000) work contradicts the 6x hypothesis . . . As a result of these findings, the 6x hypothesis needs to be re-evaluated with respect to olfaction." EPA also does not sufficiently consider indirect impacts—impacts to habitat and food supply that can be critically important.

2. EPA fails to consider real-world exposures. EPA bases its exposure assessments on a highly simplified model based on a small watershed. This model does not account for multiple users in a larger watershed. Moreover, EPA acknowledges that it is completely unable to model exposures in urban areas, where impervious surfaces greatly enhance pollutant transport. The analysis of carbaryl states "We don't have data to quantify use on noncrop sites or the capability to model runoff from homeowner uses, but we presume that such uses could contribute to the exposure and risks of at least some of these ESUs [Evolutionarily Significant Units]." (USEPA 2003b) Even more telling is EPA's contradictory conclusion after trying to adapt its agricultural runoff model for urban uses of fenbutatin-oxide and finding that the model predicts unacceptable levels: "At this point, I am out of anything resembling data, but based on my best professional judgment and the reasons described below, I conclude that there will be no effect of either of these products on listed Pacific salmon and steelhead, or any other listed fish." (USEPA 2002)

EPA also fails to make full use of USGS detection information. The USGS has conducted studies of surface water in 59 watersheds across the United States, and these data can provide valuable insight on likely exposures. EPA's effects determination on carbaryl did not take into account USGS findings of increasing carbaryl in salmon streams in the Puget Sound region. EPA made a determination of "not likely to adversely affect" for Puget Sound Chinook without addressing this evidence of alarming increases in both use and stream concentrations in Puget Sound salmon watersheds.

In the face of this lack of analysis, EPA regularly errs on the side of allowing continued pesticide use or assuming no effect. EPA's analysis of carbaryl use in the urbanized Puget Sound region states, "We conclude that carbaryl may affect but is not likely to adversely affect on [sic] the Puget Sound chinook salmon ESU. Our determination is based on the low amount of crop acreage on which carbaryl might be used within this ESU. However, homeowners also could contribute to use of carbaryl within these counties." In this case, EPA is aware of the potential impact of urban use but chooses to ignore it.

3. EPA disregards the impacts of pesticide "inert" ingredients and degradation products. The minimal battery of tests EPA uses to evaluate aquatic toxicity are conducted only on the product's active ingredient, which often composes only a small portion of the actual product. Thus, the toxicity of the full product formulation remains unknown. EPA states in the carbaryl effects determination, "we do not have aquatic data on most formulated products, although we often have testing on one or perhaps two formulations of an active ingredient." Moreover, EPA does not sufficiently consider the toxicity of degradation products. In the case of carbaryl, its primary degradation product, 1-napthol, is known to have immune system and other effects.

4. EPA turns a blind eye to additive and synergistic effects. Many pesticides have amplified effects in the presence of other toxic chemicals. As a carbamate pesticide that is known to affect nervous system function by depressing the enzyme acetylcholinesterase, carbaryl is a prime candidate for consideration in the context of other neurotoxic pesticides. Laboratory studies have shown that carbamate and organophosphate pesticides can have additive and synergistic effects, and field studies have shown toxic effects when these pesticides are present in combination. Consideration of chemical combinations was mandated for food uses of pesticides by the Food Quality Protection Act. When it comes to fish and wildlife, however, EPA, acts as though exposures to fish and wildlife occur one chemical at a time — not even close to a real-world scenario.

EPA needs to look closely at urban use of carbaryl in the Pacific Northwest. Increased use, as indicated by sales figures in King County, may explain rising levels in Thornton and Fanno Creeks.

Recommendations

Clearly, EPA has a long way to go in order to effectively assess and safeguard against the impacts of carbaryl and other pesticides on water quality and salmon. We call on EPA to change its perspective, overhaul its methods, and consider the real-life threat that these pesticides pose. In particular, EPA must take a hard look at the impacts of continuing to allow the use of the highly toxic pesticide carbaryl on food crops, around our homes and schools, and in our parks.

We call on EPA to do the following:

1. Thoroughly evaluate the ecological effects of carbaryl products and other pesticides. In its risk assessments and effects determination, EPA has failed to adequately consider the effects of current and allowed uses of carbaryl on salmon populations. EPA must redo its risk assessment and effects determination and include the following elements:

- analysis of sublethal effects including effects on behavior, immune response, hormonal systems, and reproduction, as well as mutagenicity and carcinogenicity;
- consideration of indirect effects, such as harm to food supply;
- examination of real-world exposures, including those from urban uses and combined exposures from multiple uses;
- analysis of the effects of the full product formulation, including so-called "inert" ingredients; and
- consideration of additive and synergistic effects.

EPA must also ensure that it uses only accurate information about usage patterns. Where reliable information is not available, EPA must make conservative assumptions about usage. EPA must also acknowledge that usage patterns can change greatly from year to year. Finally, EPA should make full use of U.S. Geological Survey detection information. As this report shows, surface water detection data can provide valuable information about the extent to which salmon and steelhead are exposed to a pesticide.

2. Consult with NOAA Fisheries on all potentially harmful uses of carbaryl. In its first analysis of carbaryl's harm to salmon, EPA ignored critical risk factors including its urban use. By ignoring these risks, EPA determined that carbaryl use in a number of areas, including Puget Sound, was insufficient to harm salmon. Once EPA revises its effects determination, it must engage in a full consultation with NOAA Fisheries for carbaryl effects in Puget Sound and other areas where there is potential for harm.

3. Eliminate uses of carbaryl that threaten salmon and human health. A ban on all carbaryl uses is the best way to ensure that this potent poison gets out of our streams, food, and homes. EPA must expedite the consultation process and respond to the fifteen public health, farmworker, beekeeping, and environmental organizations who recently petitioned EPA to cancel all uses of carbaryl.

4. Stop this toxic tradeoff by supporting development of alternatives to carbaryl and other pesticides. Alternatives to carbaryl for lawn care are well established, and EPA can play a role in encouraging their use. EPA can also support research on alternatives to carbaryl and other pesticides in agriculture. In the Northwest, a number of local government agencies have developed natural yard care programs that emphasize lawn health rather than pesticide applications (SPU and King County 2004, RCCRS). Local government agencies have concluded that many insecticide applications for crane fly are unnecessary and that cultural, mechanical, and biological approaches exist and can often be sufficient (e.g. McDonald 1999).

Our nation's laws are designed to ensure that our land and water remain healthy for people and fish and wildlife, and that endangered species may recover. The plight of salmon and the role that pesticides play in their decline have challenged EPA and NOAA Fisheries to upgrade their science and for the first time assess and protect against the adverse impacts these pesticides have on salmon. So far, EPA has not only failed to meet that challenge, but has proved itself irresponsible when it comes to being willing to upgrade its methods and take concrete steps to protect salmon. With this report, we have argued a case for strong action to address the threat of carbaryl. EPA has the authority and the responsibility to take the next step: assess the real impacts of carbaryl and end its use.

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