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Pesticide Use and Toxicology in Relation to Wildlife: Organophosphorus and Carbamate , Compounds

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U.S. Department of the Interior, Fish and Wildlife Service

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Contents

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Pesticide Use and Toxicology in Relation to Wildlife: Organophosphorus and Carbamate Compounds

by

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Introduction

The use of organophosphorus and carbamate pesticides has increased markedly during the past two decades. Currently, more than 100 different organophosphorus and carbamate chemicals are registered as the active ingredients in thousands of different pesticide products in the United States. More than 160 million acre-treatments of these pesticides are estimated to be applied to agricultural crops and forests each year. Clearly, these two groups of chemicals constitute a major portion of all pesticides used today.

Organophosphorus and carbamate compounds have histories dating back long before their use as pesticides. Carbamates were developed during investigation of "ordeal" poisons used in Africa and made from the calabar bean, which contains the only known naturally occurring carbamate ester (Kuhr and Dorough 1976). The insecticidal activity of carbamates was discovered in 1931 and developed in the mid-to-late 1940's. Large quantities were being produced and used by the late 1950's (Kuhr and Dorough 1976). Although much research on organophosphorus compounds was done in the 19th century, the insecticidal activity of these chemicals was not discovered until 1937 (Eto 1974). In Germany, during World War II, the compounds were rapidly developed as insecticides, and during the 1950's the commercial use of organophosphates expanded markedly (Eto 1974). Presently, organophosphorus and carbamate pesticides are used as insecticides, herbicides, nematicides, acaricides, fungicides, rodenticides, and bird repellents throughout the world.

The discovery that organochlorine pesticides, such as DDT, are highly persistent, bioconcentrate in food chains, and can severely affect whole populations or species of wildlife has led to bans and use restrictions (Stickel 1975). The decreased use of organochlorine pesticides has further expanded the market for the less-persistent organophosphates and carbamates (Murphy 1975; Stickel 1975). Today, organophosphorus and carbamate pesticide use is widespread on agricultural crops, rangelands, forests, and wetlands, and undoubtedly exposes many wildlife species to chemical hazards. Organophosphorus compounds represent the largest group of insecticides known (McEwen and Stephenson 1979). During the past decade, there has been an increase in the number of reports of wildlife die-offs related to organophosphorus and carbamate pesticide use. This handbook summarizes available information on organophosphorus and carbamate pesticides in the wildlife toxicology literature and relates those data to potential hazards to wildlife by examining toxicity, environmental persistence, and use patterns of the pesticides included.

Sources of Information

Chemicals included in this handbook are organophosphorus or carbamate compounds, and most, but not all, inhibit cholinesterase activity. All compounds are registered by the U.S. Environmental Protection Agency (EPA) as an active ingredient of a product used in the United States (Office of Pesticide Programs 1982). Some of these compounds, although still registered by EPA, are no longer in production. The primary common names for each chemical are generally those given in Blalock et al. (1979), adopted by the American National Standards Institute, or are names accepted by the International Organization for Standardization, British Standards Institution, or the Weed Science Society of America. K. L. Loening, Director of Nomenclature, Chemical Abstract Service, provided Chemical Abstract Service registry numbers (CAS numbers) and chemical names according to the International Union of Pure and Applied Chemists (IUPAC) rules of organic nomenclature; however, I assume all responsibility for errors in this publication. The IUPAC chemical names are also the Chemical Abstract Service names for the 1967–71 indexes. Other common and trade names are from Berg (1982), Thomson (1982), and Beste (1983). Trade names are used only to enable the reader to reference a particular chemical, and the use of trade names does not constitute endorsement by the U.S. Department of the Interior. Chemical properties, field applications, and available formulations are referenced in Eto (1974), Worthing (1979), Kenaga (1980), Caswell et al. (1981), Berg (1982), Page and Thomson (1982), Thomson (1982), and Beste (1983), and in individual chemical manufacturer's information bulletins.

The organophosphorus and carbamate pesticides included in this publication were grouped on the basis of toxicity and estimated field use. Because often few or no toxicity data were available for wildlife species, it was necessary to use the acute oral rat median lethal dose (LD50) values for acute toxicity comparisons among chemicals. The lowest (most toxic) LD50's for either male or female rats, primarily referenced in Berg (1982), were grouped into five toxicity classes. These toxicity classes were developed from those used by Hill et al. (1975) to classify median lethal dietary concentrations (LC50) of a toxicant. This is a relative rating system arranged geometrically, and the divisions are the same as those used by Hill et al. (1975), only applied to the median lethal dose. These classes are

I. Extremely toxic (LD50 ≤ 40 mg/kg)
II. Highly toxic (LD50 41–200 mg/kg)
III. Moderately toxic (LD50 201–1,000 mg/kg)
IV. Slightly toxic (LD50 1,001–5,000 mg/kg)
V. Relatively nontoxic (LD50 > 5,000 mg/kg)

Each pesticide was classified according to its estimated annual field use and grouped into one of six use classes based on acre-treatments:

I. > 10,000,000 acre-treatments
II. 5,000,001–10,000,000 acre-treatments
III. 1,000,001–5,000,000 acre-treatments
IV. 500,001–1,000,000 acre-treatments
V. 100,001–500,000 acre-treatments
VI. ≤ 100,000 acre-treatments

Annual use estimates are based primarily on agricultural crops and secondarily on forest use. Other types of use such as industrial, public health, and most right-of-way use, are not included. Limitations of the pesticide use estimates are discussed in a later section of this handbook.

The toxicity data were obtained from several sources, and whenever possible, original research papers were used instead of general references, which usually did not include information on sex, age, compound purity, and other details of the testing procedure. Major sources of toxicity data included Gaines (1969), Tucker and Crabtree (1970), Schafer (1972), Hill et al. (1975), Kenaga and Morgan (1978), Worthing (1979), Berg (1982), Beste (1983), Hudson et al. (1984), and Hill and Camardese (1986).

Often, birds and mammals referred to in the technical literature were not identified to species level; in those instances, the most taxonomically specific name given in the literature is used. The ages of test animals are given in months when available, or as adult (A) or immature (I). When the test animal's sex (M or F) or age was not given it is reported as unknown (U). The same is true of chemical purity.

Field-test data and wildlife die-off information were obtained from the published literature, the EPA Pesticide Incident Monitoring System (PIMS), and the U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, pesticide files. Water solubility data were obtained from Windholz (1976), Worthing (1979), Kenaga (1980), and Berg (1982), and from chemical manufacturer's information bulletins. Water solubilities were generally for temperatures between 20 and 25°C. For each chemical that water solubility data were available, bioconcentration factors (BCF) using both the terrestrial–aquatic (t) and flow-through water systems (f) models were predicted using equations published by Kenaga (1980). Between-chemical comparisons were made using BCF(f)'s, which are generally one order of magnitude higher than BCF(t)'s. Chemicals classified here as "restricted use" represent active ingredients that were included in any product that the EPA classified as a restricted-use pesticide. This list consists of federally registered restricted products as of April 1983, and in some cases, not all products containing the same active ingredient have the same restriction status.

Arrangement and Use of the Handbook

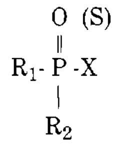
The organophosphorus and carbamate pesticides included in this handbook are classified according to their primary pesticidal activity. Those pesticides classified as insecticides also include nematicides, acaricides, and anthelmintic agents. Included with herbicides are defoliants and plant-growth regulators. Fungicides are grouped separately. Chemicals may be accessed alphabetically by common name within the appropriate type of pesticidal activity. If the common name or activity type is not known, the pesticide may be accessed by other names through the cross reference and index provided in Appendix D.

Because of the large number of literature references, those in tabular charts are accessed by numbers and listed alphabetically in the Reference section. Scientific names mentioned in the text and acute oral rat LD50's are listed in Appendixes A and B, respectively.

Properties of Organophosphorus and Carbamate Pesticides

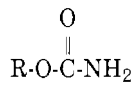
Chemical and Physical Properties

Organophosphorus pesticides have the following general chemical structure:

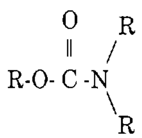


where the R-groups may be alkoxy, alkyl, aryl, or amide. The X-group is generally a carboxylating, cyanide, thiocyanate, phosphate, halide, phenoxy, or thiophenoxy group (Eto 1974; Aldridge 1981; Berg 1982; Stuart and Oehme 1982).

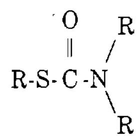
Carbamate insecticides have the general structure:



and may have a variety of R-groups. Carbamate herbicides (*a*) and thiocarbamates (*b*) have the structures:

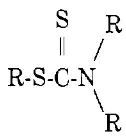


(*a*)



(*b*)

Dithiocarbamates include metallic fungicides and have the following basic structure:



Organophosphorus and carbamate pesticide solubilities vary according to the solvent. Most are soluble to some extent in organic solvents, but they are usually less soluble in water. Carbamates and organophosphates generally have low environmental persistence, especially when compared with organochlorine pesticides. Their degradation is often accelerated by an increase in temperature or alkalinity.

Technical-grade material is a relatively pure form of a pesticide that is processed to enhance its effectiveness, storage stability, or ease of handling and application. This processing results in a particular formulation of the pesticide that has a unique label and is registered for specific sites (such as a specific crop) by the EPA. Formulations often differ from the technical material in physical and toxicological properties. Whenever possible, in this handbook the formulation type is specified when citing toxicity data. The standard formulations and abbreviations used in this handbook include bait (B), dust (D), emulsifiable concentrate (EC), granular (G), spray (S), spray concentrate (SC), soluble powder (SP), ultra-low volume (ULV), and wettable powder (WP). Numbers preceeding formulation abbreviations generally refer to the number of pounds of active ingredient (AI) per gallon or the percentage of active ingredient in a formulation.

Biochemical Properties and Mode of Action

Although organophosphorus and carbamate pesticides are chemically different, exposure to either of these groups of pesticides usually results in the inhibition of cholinesterase enzyme (ChE) activity.

Acetylcholine (ACh), the neurotransmitter secreted by cholinergic postganglionic neurons, allows for transmission of nerve impulses across the synapse. Acetylcholinesterase (AChE; Enzyme Commission Number 3.1.1.7) is the enzyme responsible for the breakdown of ACh, thereby terminating the electrochemical connection between two nerve cells. Acetylcholinesterase is found in highest concentration in the nervous system, but it also occurs in erythrocytes. Butyrylcholinesterase (BChE; Enzyme Commission Number 3.1.1.8), also called pseudocholinesterase, is found in blood sera; although its physiological function has not been well defined, it is useful as an indicator of organophosphate and carbamate exposure (Hill and Fleming 1982).

Organophosphorus chemicals phosphorylate acetylcholinesterase in an irreversible reaction that inhibits the activity of cholinesterase to hydrolyze the neurotransmitter at the nerve synapse. The accumulation of acetylcholine results in continuous nerve firing and eventual failure of nerve impulse propagation. Respiratory paralysis is generally the immediate cause of death (Murphy 1975). Brain cholinesterase activity is used in the diagnosis of organophosphate and carbamate poisoning with a reduction of 20% of normal activity indicating exposure. A cholinesterase inhibition of 50% or more is considered the diagnostic threshold for determining the cause of death (Ludke et al. 1975). Because of the irreversible nature of the pesticide–enzyme binding reaction characteristic of organophosphate poisoning, recovery from a sublethal organophosphate exposure depends on synthesis of more cholinesterase. There is evidence that recovery of cholinesterase activity in plasma is as fast or faster than in the brain (Fleming and Bradbury 1981).

Carbamylation of acetylcholinesterase, caused by carbamate poisoning, also inhibits its activity. Unlike the organophosphate–enzyme complex, the carbamylated enzyme is destabilized through biochemical processes, and restoration of enzyme activity can occur. Therefore, the inhibition of cholinesterase activity caused by carbamate poisoning is reversible to a greater degree than when caused by organophosphate poisoning. Detailed information on the mechanism of acetylcholinesterase inhibition may be found in O'Brien (1976).

In addition to anticholinesterase activity, some organophosphorus and carbamate pesticides have other adverse biochemical effects. A number of organophosphates have been determined to inhibit neurotoxic esterase, an enzyme that has not been isolated and whose biochemical and physiological functions in nerve tissue are unknown

(Metcalf 1982). Delayed neurotoxicity is believed to involve the inhibition of neurotoxic esterase and subsequent degeneration of the distal portions of the large axons in the peripheral nervous system and spinal cord (Davies and Richardson 1980). The result of exposure is ataxia and paralysis caused by axonal degeneration and demyelination; however, the specific relation between neurotoxic esterase inhibition and distal axonopathy is not well understood. Johnson (1974) proposed that delayed neurotoxicity requires not only phosphorylation of the esterase but also hydrolysis of one remaining phosphoryl-ester bond. Studies that have screened chemicals in a variety of species have found the domestic chicken (hen) to be the species of choice for delayed neurotoxicity studies due to its sensitivity (Davies and Richardson 1980). Young animals and certain species, including the laboratory rat, appear to be more resistent to delayed neurotoxic effects (Davies and Richardson 1980). Little information is available on delayed neurotoxicity in wildlife species; however, species differences can be great, and the capacity to produce delayed neurotoxicity is widespread among organophosphates (Metcalf 1982).

Other sublethal biochemical effects have been described for organophosphates, such as impaired reproduction in birds through possible hormonal effects and reduced tolerance to cold stress (Rattner et al. 1982). Embryotoxicity and teratogenic effects have been demonstrated for some organophosphates (Hoffman and Albers 1983), and some have been shown to cause changes in brooding behavior or nest attentiveness of birds—changes that could result in death of the young (Grue et al. 1983; White et al. 1983*a*).

Wildlife Toxicology

Toxicity Testing

The standard method of expressing a chemical's toxicity has been to quantify the dose–response relation using toxicity testing. Normally, the first test conducted on a newly developed pesticide is to determine the single-dose acute oral LD50. The LD50 value quantifies the response of a test animal, measured in percent mortality, as a function of the dosages of the chemical administered. This LD50 represents the median lethal dosage that produces 50% mortality in the experimental population. Generally, the 95% confidence limits (CL) will also be reported with the LD50. Several geometrically arranged dosages (e.g., 2, 4, 8, 16, etc.) are administered in milligrams (mg) per kilogram (kg) of body weight, and the data are analyzed by probit analysis. The result of this analysis is a linear dose–response relation that can be used to obtain dosages that produce the LD50 or any other percent mortality dosage, such as a LD95. For statistical purposes, the best lethal dosage estimates are those between LD16 and LD84, and it is recommended that experiments be specifically designed for determining LD values outside this range.

Recently, subacute toxicity studies have been developed that expose the test animal to a chemical by mixing a known amount of the toxicant into the food (Hill and Camardese 1982). This subacute test permits voluntary ingestion of the treated food and allows feeding behavior and other responses of the test animal to be evaluated (Hill and Camardese 1982). The LC50 of the chemical in the diet that produces 50% mortality in the test population provides an estimate of a species' vulnerability to a contaminated diet (Heinz et al. 1979; Hill and Camardese 1982). The 5-day subacute toxicity test has been applied to several bird species and has provided much information about the toxic effects of chemicals by field exposure.

A number of other tests can be conducted to examine different aspects of a chemical's toxicity. Chronic toxicity studies normally involve low-level dietary exposure of an animal over a long period, that is, 90 days to 2 years. An acute dermal (AD) LD50 can be determined to evaluate a pesticide's dermal toxicity. Evaluation of a chemical's hazard to aquatic life is generally done using an LC50 test in which the value reported is the concentration in water lethal to 50% of the test population over a given time, usually 96 h (Johnson and Finley 1980). Carcinogenic, mutagenic, teratogenic, and reproductive studies may be conducted to determine adverse sublethal effects of chemical exposure. These types of studies are important in evaluating chemical hazard; however, those types of data are frequently not available for many pesticides.

Extrapolating toxicity data to predict the potential hazards of chemicals to wildlife has severe limitations. Studies have indicated that pre-exposure to one organophosphate may potentiate the toxicity of another (Murphy 1969; Grue et al. 1983). Exposure may inhibit enzyme systems, other than AChE, that detoxify organophosphorus compounds and thereby increase the toxic effects of another exposure. The chemical's formulation, carrier, persistence, potential to bioconcentrate, rate and method of application, and substrate of application affect its potential environmental hazard. Biological factors that may potentially affect a pesticide's hazard to wildlife include species, sex, age, nutritional status, health, diet, activity period, and other physiological and behavioral variables. Obviously, no single toxicity test can take into account all these factors. Therefore, predictions of the possible adverse environmental effects of a pesticide are usually made by evaluating the available data, which are often incomplete. Moreover, toxicity tests are often conducted using different protocols, which may yield variable results.

Wildlife Die-offs

Organophosphorus and carbamate pesticides have relatively low environmental persistence; therefore, their chronic toxicity is of lesser importance in their overall hazard to wildlife populations compared to the more persistent organochlorines. Wildlife die-offs caused by organophosphates or carbamates are generally incidences of acute poisoning, and what constitutes a wildlife die-off may be somewhat arbitrary with respect to the actual number of individuals killed. A wildlife die-off usually takes place over a relatively short time, occurs in a defined geographic area, and has a common agent responsible for the mortality. The effect of a die-off on a population depends on the population size and its demography in relation to the number of individuals killed.

Diagnosis of organophosphate- or carbamate-caused wildlife mortality requires that brain cholinesterase activity be determined for killed and normal specimens of the same species, from the same general locale. Final diagnosis of death is confirmed by detecting organophosphate or carbamate residues in the gastrointestinal tract of the specimen. Changes in brain cholinesterase activity after death depend on the chemical involved and the ambient temperature (Hill and Fleming 1982). Reactivation of cholinesterase activity may occur in the brain following death by exposure to reversible cholinesterase inhibitors, that is, carbamates (Hill and Fleming 1982). It is critical that a sufficient number of controls be obtained to determine "normal" cholinesterase activity and that they are handled, frozen, and shipped identically to those individuals collected at the suspected die-off. Specimens should be handled with rubber gloves to avoid possible dermal exposure to the collector, individually labeled and wrapped in an airtight plastic bag, and frozen as soon as possible. Notes should be made on the number of individuals of each species killed, the possible contaminants that may be involved, symptoms of affected survivors, individual weights, and the handling procedures of specimens collected, including controls. Detailed reviews of field sampling, cholinesterase activity determination, assay interpretation, and interpretation of wildlife die-off data can be found in the literature (Heinz et al. 1979; Hill and Fleming 1982).

Pesticide Risks to Wildlife

The risk that an organophosphorus or carbamate pesticide poses to a wildlife population is a function of the toxicity of the compound, where it is applied in relation to wildlife habitat, how much is applied over a given time, how long the parent compound or its toxic metabolites persist in the environment, and whether it bioconcentrates in food chains. These factors interact with the behavior and food habits of a species to produce a lethal, sublethal, or a no-effect response in those individuals exposed. Risk assessment relates the concentration and duration of a chemical in various parts of the environment to chemical concentrations that are toxic to an organism in its food or water (Kenaga 1982). Realistic models of environmental hazards involve many variables, most of which are held constant or eliminated in laboratory toxicity testing. Therefore, extrapolation from laboratory studies to the field is usually approximate at best and sometimes not possible.

Wildlife die-offs caused by organophosphates (Grue et al. 1983) or carbamates (Hill and Fleming 1982) have been summarized in the literature. Currently, there is a paucity of evidence of significant population changes for any wildlife species that may be attributed to organophosphate use (Grue et al. 1983). Literature reviewed for this handbook suggests that this is also the case for carbamates. However, available information indicates that even when applications of certain organophosphorus and carbamate pesticides are made at the recommended rate, on a registered crop or other site, wildlife may be killed. The overall demographic impacts of these die-offs, as well as the sublethal effects on wildlife, are not well understood.

Pesticide users are generally most interested in maximizing economic benefits of pesticide use; however, it is the applicator's responsibility to apply these chemicals in accordance to the label and to understand their potential adverse effects. Pesticide users must also understand that merely following the instructions on the product label will not ensure that wildlife will not be killed. Prior to application of a pesticide, environmental circumstances should be carefully evaluated and the benefits of use should be weighed against potential adverse effects. The season, with respect to migratory, breeding, and nesting species, should be considered, as well as the specific habitats to be treated. Weather conditions influence aerial drift and subsequent pesticide runoff into ponds and wetlands inhabited by fish and wildlife. The time for spraying should be selected to avoid those periods when birds are present. Recommended application rates should not be exceeded, and careful application should be made to avoid overspray. Applications of pesticides to crops can be made by leaving buffer zones (without spray or using a less-hazardous pesticide) around field perimeters where wildlife tend to feed and nest. Finally, the use of pesticides less hazardous to nontarget species, but equally effective against target species, will help minimize wildlife mortality.

Pesticide Field-use Estimates

Understanding the quantity and geographic extent of a pesticide's use is important for determining its potential environmental hazard. This section summarizes organophosphorus and carbamate pesticide use estimates obtained from Smith and Vlier (1983).

Methods and Data Sources

Organophosphorus and carbamate pesticide profile data in this handbook include estimates of annual acre-treatments and geographic areas of use for each organophosphorus and carbamate pesticide. The acres treated include private agricultural applications, pest-control applications made by Federal agencies (U.S. Fish and Wildlife Service, U.S. Bureau of Land Management, U.S. Forest Service, U.S. Department of Agriculture, Animal and Plant Health Inspection Service), and State and other private applications made under the authority of Federal agencies.

Estimates of private agricultural acre-treatments were derived from pesticide surveys and other information readily available within the U.S. Environmental Protection Agency. Estimates of pest-control applications made by Federal agencies were obtained directly from each agency.

Pesticide profile data presented in this section do not include estimates of pest-control treatments made on industrial locations, military installations, and right-of-ways. Right-of-way applications could be substantial for certain pesticides; however, the primary sites for these particular chemicals are agricultural crops, forests, and rangelands. In addition, the estimates reported do not include home and garden applications, applications made for public health purposes, and applications to livestock. State and local pesticide uses were included when the applications were made in cooperation with Federal agencies.

Average annual acre-treatment estimates are based on 1978–1981 pesticide-use data and were identified by site (e.g., corn, cotton, potatoes, etc.) and aggregated. Three-year averages (1979–1981) were available for most chemical–site combinations, although survey data on some crops were limited so that only 2-year averages could be developed during that period.

Organophosphorus and carbamate pesticide use estimates are reported in acre-treatments instead of pounds of active ingredient. Acre-treatments reflect the geographic extent of a pesticide's use and take into account repeated applications. Acre-treatments were obtained by multiplying the number of acres treated with a pesticide by the number of applications.

Because this handbook was written for pesticide users and crops are still thought of as planted and treated in acres rather than hectares, acre-treatments are reported in Tables 1–3 instead of metric equivalents. Furthermore, pesticide formulations are reported in the exact units in which they are marketed.

Organophosphorus and Carbamate Pesticide Use

Organophosphorus and carbamate pesticide use was estimated for seven geographic regions of the United States (Fig. 1). Regional and total United States estimates of organophosphorus pesticide use were made for each chemical by averaging annual use estimates from 1978–1981 (Table 1). Annual carbamate field-use estimates, obtained from 1978–81 figures, were also made on a regional and total United States basis (Table 2).

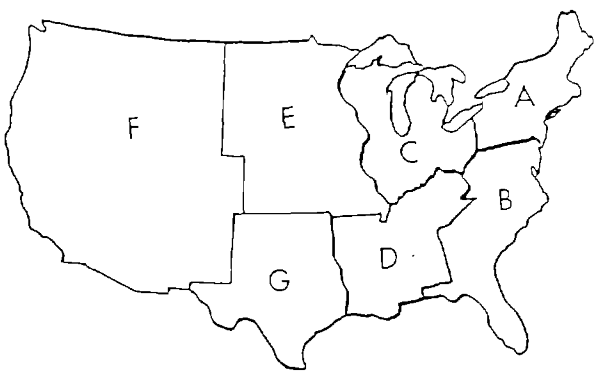


Fig. 1. Regional boundaries for organophosphorus and carbamate pesticide-use data.

Acres of cropland planted with seeds treated with organophosphorus or carbamate pesticides were also estimated on an annual and regional basis (Table 3). Corn, cotton, and soybeans were the crops represented by the largest acreages planted with treated seeds. Table 3 also ranks the acreage planted for each of these crops for each chemical.

Of the pesticide-use applications included in the analysis (i.e., private agricultural applications and Federal applications), agricultural use generally composed more than 99% of the field use for most organophosphorus and carbamate pesticides. Agricultural use of malathion, temephos, and trichlorfon composed about 46, 18, and 55% of the total estimated annual use, respectively. Nonagricultural field use of malathion and temephos is likely for mosquito control, whereas trichlorfon is used as a forest-insect spray to control budworms and gypsy-moth larvae. Agricultural use of carbaryl and thiram was estimated to be about 86 and 70% of the total estimated use, respectively. Large acreages of rangelands and forests are treated with carbaryl for grasshopper and forest-pest control. Thiram is used on nursery stock and ornamentals in addition to its use on crops.

Of the estimated more than 89 million acre-treatments of organophosphates applied each year, more than 50% of the use involves six chemicals: methyl parathion, parathion[1], terbufos, fonofos, and azinphos-methyl. These chemicals are among the most toxic organophosphorus pesticides when measured by their acute oral rat LD50.

[1]Some of the survey data used did not adequately distinguish between use of methyl parathion versus parathion and diallate versus triallate. See Limitations of the Data section.

Table 1. *Annual organophosphorus pesticide applications estimated by geographic region.*

Common name	Annual Estimated U.S. Use[a]	Region							
		A	B	C	D	E	F	G	Other
	acre-treatments × 1000								
Acephate	2,492	770	530	0	480	180	241	281	0
Akton	0	0	0	0	0	0	0	0	0
Aspon	0	0	0	0	0	0	0	0	0
Azinphos-methyl	5,861	740	985	550	860	155	815	1,410	65
Bensulide	1	0	0	0	0	0	0	0	0
Bomyl	0	0	0	0	0	0	0	0	0
Bromophos	0	0	0	0	0	0	0	0	0
Butonate	0	0	0	0	0	0	0	0	0
Carbophenothion	210	20	35	0	0	0	15	130	0
Chlorfenvinphos	0	0	0	0	0	0	0	0	0
Chlorpyrifos	4,041	15	220	1,250	440	1,795	115	180	30
Coumaphos	0	0	0	0	0	0	0	0	0
Crotoxyphos	0	0	0	0	0	0	0	0	0
Crufomate	0	0	0	0	0	0	0	0	0
Cythioate	0	0	0	0	0	0	0	0	0
DDVP	0	0	0	0	0	0	0	0	0
DEF	0	0	0	0	0	0	0	0	0
Demeton	290	50	55	20	5	10	145	15	0
Demeton-methyl	0	0	0	0	0	0	0	0	0
DEP, 2,4-	0	0	0	0	0	0	0	0	0
Dialifor	0	0	0	0	0	0	0	0	0
Diamidfos	0	0	0	0	0	0	0	0	0
Diazinon	951	60	80	115	50	70	490	40	20
Dicapthon	0	0	0	0	0	0	0	0	0
Dichlofenthion	0	0	0	0	0	0	0	0	0
Dicrotophos	1,790	0	15	0	600	0	100	1,080	0
Dimethoate	3,781	240	440	80	510	575	1,236	610	0
Dioxathion	30	0	0	0	25	0	5	0	0
Disulfoton	2,020	60	295	65	70	230	845	430	10
EPN	3,860	0	220	90	2,680	0	35	835	0
Ethephon	0	0	0	0	0	0	0	0	0
Ethion	781	10	701	15	0	0	60	0	0
Ethoprop	1,431	15	470	240	10	695	0	0	0
Famphur	0	0	0	0	0	0	0	0	0
Fenamiphos	130	0	80	5	30	0	0	0	0
Fenitrothion	0	0	0	0	0	0	0	0	0
Fensulfothion	170	15	110	10	5	10	25	0	0
Fenthion	0	0	0	0	0	0	0	0	0
Fonofos	6,691	220	100	2,825	30	3,260	140	110	0
Glyphosate	3,159	46	243	110	371	254	804	1,201	25
Isofenphos	100	0	0	35	0	60	0	10	0
Malathion	4,486	37	203	85	410	757	1,845	1,109	0
Methamidophos	1,030	90	265	0	10	25	520	0	125
Methidathion	860	20	10	65	15	170	285	180	130
Methyl parathion[b]	22,672	710	3,100	435	6,910	2,430	2,772	6,190	55
Methyl trithion	0	0	0	0	0	0	0	0	0
Mevinphos	170	0	125	0	0	5	40	0	0
Monocrotophos	2,500	5	820	0	620	0	370	405	60
Naled	185	2	108	0	0	0	80	0	0
Oxydemeton-methyl	270	10	10	10	5	50	170	5	10
Parathion[b]	—	—	—	—	—	—	—	—	—
Phorate	4,691	60	235	1,390	10	2,390	425	80	105
Phosalone	3,830	60	1,320	20	1,270	0	605	385	0

Table 1. *Continued.*

Common name	Annual Estimated U.S. Use[a]	Region A	B	C	D	E	F	G	Other
	acre-treatments × 1000								
Phosfon	0	0	0	0	0	0	0	0	0
Phosmet	1,130	185	230	240	0	15	290	5	0
Phosphamidon	140	50	45	5	0	0	30	0	0
Pirimiphos-ethyl	0	0	0	0	0	0	0	0	0
Profenofos	10	0	0	0	0	0	10	0	0
Propetamphos	0	0	0	0	0	0	0	0	0
Ronnel	0	0	0	0	0	0	0	0	0
Sulfotep	0	0	0	0	0	0	0	0	0
Sulprofos	450	0	20	0	240	0	105	90	0
Temephos	57	20	32	0	4	0	0	0	0
TEPP	1	0	0	0	0	0	0	0	0
Terbufos	7,921	115	360	3,360	5	2,820	80	30	5
Tetrachlorvinphos	0	0	0	0	0	0	0	0	0
Trichlorfon	347	158	0	0	0	10	90	80	0
Total	88,539	3,783	11,462	11,020	15,660	15,966	12,788	14,891	640

[a] Includes private agricultural applications and field applications by Federal agencies. Total estimated use figures are generally larger than the sums of the regions, due to incomplete regional breakdown in some data.
[b] Some of the survey data did not adequately distinguish between the use of methyl parathion and parathion. Total estimated use of both of these chemicals is identified under methyl parathion.

Table 2. *Annual carbamate pesticide applications estimated by geographic region.*

Common name	Annual Estimated U.S. Use[a]	Region A	B	C	D	E	F	G	Other
	acre-treatments × 1000								
Aldicarb	1,990	190	50	40	270	140	420	350	30
Aldoxycarb	0	0	0	0	0	0	0	0	0
Aminocarb	0	0	0	0	0	0	0	0	0
Asulam	240	0	170	0	2	35	0	30	5
Barban	780	0	0	0	0	675	105	0	0
Bendiocarb	0	0	0	0	0	0	0	0	0
Benomyl	4,531	210	1,700	340	600	55	661	445	80
Bufencarb	52	0	0	0	0	10	42	0	0
Butylate	15,833	420	931	6,181	551	7,401	0	0	0
Carbaryl	6,766	1,494	1,974	823	461	956	1,159	666	40
Carbofuran	13,663	1,085	1,781	3,340	1,121	4,730	761	770	60
CDEC	10	0	0	0	0	0	5	0	0
Chlorpropham	300	0	0	15	0	255	0	0	0
Cycloate	200	0	0	0	0	80	45	0	80
Desmedipham	320	0	0	0	0	210	30	0	80
Diallate[b]	—	—	—	—	—	—	—	—	—
EPTC	4,953	345	66	690	411	2,420	741	25	30
Ferbam	150	50	40	40	0	0	5	0	0
Formetanate	40	10	15	0	0	0	15	0	0
Mancozeb	2,360	850	370	50	0	215	220	270	340
Maneb	2,490	270	840	50	0	20	480	285	535
Metham	30	0	0	0	0	0	25	0	0
Methiocarb	10	3	0	0	0	0	5	0	0

Table 2. *Continued.*

Common name	Annual Estimated U.S. Use[a]	Region							
		A	B	C	D	E	F	G	Other
	acre-treatments × 1000								
Methomyl	10,631	80	5,530	415	1,740	260	1,705	800	60
Metiram	400	110	60	110	0	75	30	0	20
Mexacarbate	0	0	0	0	0	0	0	0	0
Molinate	1,390	0	0	0	480	0	440	480	0
Nabam	1	0	0	0	0	0	1	0	0
Oxamyl	490	260	130	30	5	0	45	0	15
Pebulate	430	5	170	5	20	0	210	0	15
Phenmedipham	200	0	0	0	0	95	20	0	80
Propham	0	0	0	0	0	0	0	0	0
Propoxur	120	0	0	0	60	0	0	60	0
Thiobencarb	211	0	0	0	90	0	26	75	0
Thiophanate	0	0	0	0	0	0	0	0	0
Thiophanate-methyl	0	0	0	0	0	0	0	0	0
Thiram	29	11	16	3	0	3	0	0	0
Triallate[b]	2,990	0	0	0	0	2,615	370	0	5
Vernolate	1,390	0	680	170	255	150	30	60	0
Zineb	180	30	95	0	0	0	30	5	5
Ziram	180	0	0	0	0	0	175	0	0
Total	73,360	5,423	14,618	12,302	6,066	20,400	7,801	4,321	1,480

[a] Includes private agricultural applications and field applications by Federal agencies. Total estimated use figures are generally larger than the sums of the regions, due to incomplete regional breakdowns in some data.
[b] Some of the survey data did not adequately distinguish between the use of triallate and diallate. Total estimated use of both of these chemicals is identified under triallate.

Table 3. *Estimated annual acres planted with seed treated with organophosphorus and carbamate pesticides.*

Common name	Annual Estimated U.S. Use[a]	Region							Crop use rank		
		A	B	C	D	E	F	G	Corn	Cotton	Soybeans
	acres planted with treated seeds (× 1000)										
Organophosphates											
Acephate	305	5	5	0	230	0	35	30	2	1	—
Diazinon	1,150	320	10	680	5	125	10	0	1	2	3
Disulfoton	1,020	0	25	0	345	0	75	575	—	1	—
Malathion	2,060	85	185	920	140	670	10	50	1	3	2
Monocrotophos	40	5	0	0	0	0	10	25	2	1	—
Phorate	225	0	5	25	15	15	60	105	2	1	3
Total	4,800	415	230	1,625	735	810	200	785			
Carbamates											
Aldicarb	160	0	15	0	60	0	20	65	—	1	—
Carbaryl	10	0	0	0	0	0	0	10	—	1	—
Carbofuran	225	15	90	75	5	35	5	0	1	3	2
Methiocarb	50	5	10	20	15	0	0	0	1	—	—
Thiram	210	0	60	30	50	15	5	0	2	—	1
Total	655	20	175	125	130	50	30	75			

[a] Total estimated use figures are generally larger than the sums of the regions, due to incomplete regional breakdown in some data.

Phorate, malathion, chlorpyrifos, EPN, phosalone, and dimethoate compose more than 25% of the estimated total field use.

On a regional basis, the north-central States (Region E) have the largest organophosphate use, primarily due to pesticide use on corn and soybeans. Those States combined with the delta States (Region D) and the south-central region (Region G) compose more than 50% of the organophosphorus pesticide field applications in the United States.

Carbamate field use is concentrated in three chemicals —butylate, carbofuran, and methomyl—that compose more than 50% of the estimated total United States carbamate use. Carbofuran and methomyl are among the most toxic carbamates. These three major-use carbamates combined with carbaryl, EPTC, and benomyl compose more than 75% of the estimated United States carbamate use.

The north-central States (Region E) also show the highest number of acre-treatments for carbamates on a regional basis. Those States plus the southeastern region (Region B) account for more than 50% of the estimated annual carbamate use.

Seed-treatment data indicate that more acres are planted with seed treated with organophosphorus pesticides than carbamates. Malathion, diazinon, and disulfoton compose most of the organophosphates used as seed treatments. Major regional use of seed-treatment pesticides occurs in the Great Lakes region (Fig. 1, Region C).

Mosquito-control treatments are not included in the field-application estimates (Tables 1 and 2) because data on applications are scarce. Information available does indicate that organophosphorus insecticides are the most widely used mosquito-control agents. Malathion, fenthion, naled, and temephos are widely used for mosquito abatement and compose the majority of insecticides used in these programs (Smith and Vlier 1983). Although highly accurate survey data are unavailable, it has been estimated that 13 million acre-treatments of malathion have been made during a single year. Estimated annual uses of naled and fenthion are in the 4–7 million acre-treatment range, and about 1–2 million acre-treatments of temephos are applied.

Limitations of the Data

The estimated annual acre-treatment data for organophosphorus and carbamate pesticides are subject to limitations that must be recognized when interpreting use figures. Annual use of pesticides will fluctuate in response to changes in chemical prices and production costs, expected crop prices, and changes in aggregate acreages grown. Furthermore, whereas some pesticides are applied on a prophylactic basis with a relatively stable use pattern, other chemicals are applied prescriptively in response to pest populations (e.g., plant, insect, and disease) that exceed economic thresholds. These factors, and problems with aggregating several pesticide surveys, make field-use estimates only approximate at best. Average annual acre-treatment numbers should not be used as absolute numbers but are provided for comparison only.

Difficulties were encountered with data concerning parathion (ethyl) versus methyl parathion and diallate versus triallate because some survey data did not adequately distinguish between the pairs of chemicals. The uncertainty of distinguishing between these chemicals resulted in joint estimates of methyl parathion and parathion (ethyl) acre-treatments and diallate and triallate acre-treatments.

Conclusions

More than 89 million acre-treatments of organophosphorus and carbamate pesticides are applied each year within the United States. These compounds are applied to agricultural lands, rangelands, and forests in every region of the country and in every State. Clearly, organophosphorus and carbamate pesticides are used extensively throughout the country. Only a small number of chemicals represent the majority of use for both groups of pesticides, despite the large number of chemicals on the market today. Of the organophosphorus and carbamate pesticides contributing to more than 50% of the total use, all but one of these chemicals are classified as highly toxic. Therefore, most of the potential hazard to nontarget species is produced by only a few widely used and highly toxic chemicals. Many factors determine whether or not the potential hazard of a chemical is realized; however, defining pesticide-use patterns is an important step in developing realistic models for assessing risk.

Chemical Summaries and Hazard Evaluations

Insecticides

Acephate

CAS #30560-19-1

Toxicity Class: III **Use Class:** III

Chemical Name: *O,S*-Dimethyl acetylphosphoramidothioate

Common and Trade Names: Orthene, Ortho 12420, Ortran, Ortril, Tornado

Action: Insecticide

Properties: Technical acephate is a colorless solid that is highly soluble in water (650,000 mg/L) and less than 5% soluble in aromatic solvents.

Field Applications and Formulations: Acephate is a systemic and contact organophosphorus insecticide used to control many insect pests including aphids, gypsy moths, leafhoppers, and cutworms. It is used on trees, rangeland, and several agricultural crops at a rate of 0.6 to 1.1 kg/ha (0.5–1.0 lb/acre) (Thomson 1982). Major-use crops are tobacco, cotton, and beans. Acephate is also widely used as a forest insecticide. It is formulated as dust (2%), granules, soluble powder (75%), spray, and wettable powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	tech	361		285
Rat	M	U	tech	945		11
	F	U	tech	866		11
Chicken	U	U	tech	852		285
Dark-eyed junco	U	A	75	106		293
Mallard	U	U	tech	350		285
	M	I	93.2	234	(186–295)	131
Ring-necked pheasant	U	U	tech	140		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			Chronic oral 30 ppm with "no effect" at 90 days	146
Rabbit	U	U	75	>10,250			40
	U	U	U	>2,000			146
Rat	U	U	tech	>2,000			40
	U	U	50	>10,000			40
	U	U	U			Chronic oral 30 ppm with "no effect" at 90 days	146

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
White-footed mouse	M	4–8	98			Oral intubation of 50 and 100 mg/kg inhibited brain ChE (45 and 56%) and basal luteinizing hormone (LH) (29 and 25%) after 4 h; dietary exposure up to 400 ppm inhibited ChE, but not LH	218
Japanese	U	0.5	98		3,275	(2,691–3,986)	122
quail	U	0.5	15.6		718	(593–868)	122

Effects of Field Applications and Field Tests on Wildlife: Aerial spraying of acephate (0.6 kg/ha) resulted in a decline in numbers of red-eyed vireos; however, significant decreases in numbers of other passerines were not observed (Bart 1979). No mortality was documented during this study (Bart 1979).

Aerial spray at a rate of 0.6 kg/ha resulted in no significant effects on numbers, survival, and reproduction of forest birds (Garton 1977; Julin and Gramlich 1978). Aerial spraying at 1.1 kg/ha (1 lb/acre) resulted in possible sickness and death of some forest birds in one study (Richmond et al. 1979). One aerial application of 0.6 kg/ha produced cholinesterase inhibition in songbirds and squirrels; however, no mortality was observed (Zinkl et al. 1980). Songbird cholinesterase activity was significantly inhibited in 19 of 19, 45 of 84, 15 of 58, and 16 of 62 songbirds analyzed from an area treated aerially at 2.2, 1.1, 1.1, and 0.6 kg/ha, respectively (Zinkl et al. 1979).

Persistence and Hazard Evaluation: Acephate is of relatively low environmental persistence and has residual insecticidal activity for 6–15 days. When applied at rates of 0.6–1.1 kg/ha, half-life estimates in plants and water range from 5 to 10 days (Bart 1979). Acephate is rapidly degraded in the soil, with a half-life of 0.5–4 days for most soil types and 6–13 days in organic muck (Chevron Chemical Co. 1977*a*).

Degradation products of acephate consist of nontoxic salts (90–95%) and a closely related insecticide, methamidophos (5–10%). Acute oral LD50's for methamidophos are an order of magnitude less than acephate, and the high toxicity of this chemical should be considered whenever acephate is applied.

Acephate is readily taken up by plants and translocated to leaves. Leaf and forest litter residues decline to nondetectable levels 1–2 months after application. It is highly soluble in water (65%) and has a very low predicted bioconcentration factor. Short half-lives in soils, plants, and water and the low potential to bioconcentrate indicate that the environmental persistence of acephate is relatively low.

Acephate has moderate to slight acute oral toxicity to mammals and birds. Oral intubation of 50 and 100 mg/kg in white-footed mice reduced plasma luteinizing hormone, although this reduction was short-lived (Rattner and Michael 1985). Several studies have demonstrated postspraying cholinesterase inhibition in birds. Available information suggests that it is of moderate to low toxicity to nontarget species with the exception of high toxicity to bees.

Akton

CAS #1757-18-2

Toxicity Class: II — **Use Class:** VI

Chemical Name: *O*-[2-Chloro-1-(2,5-dichlorophenyl)vinyl] *O*,*O*-diethyl phosphorothioate

Common and Trade Name: Axiom

Action: Insecticide

Properties: A brown liquid, soluble in most organic solvents and in water at 1.4 mg/L (Eto 1974).

Field Applications and Formulations: Akton is a nonsystemic organophosphorus insecticide used to control soil insects and chinch bugs on turf. It is formulated as an emulsifiable concentrate (0.240 kg/L; 2 lb/gal).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	89		146
Rat	U	U	U	146		11
Mallard	M	3–5	98.5	>2,000		264

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	177			146

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Production of akton has been discontinued by the manufacturer (Berg 1982), and few data are available concerning its environmental fate and persistence. Available information indicates that half-lives of akton in soils range from 57 to 84 weeks (Menzie 1974). It has low solubility in water, and its predicted bioconcentration factor is relatively high. Akton is moderately toxic to laboratory mammals; however, the high acute oral LD50 for mallards (>2,000 mg/kg) (Tucker and Crabtree 1970) suggests low toxicity for that species. Adverse effects on wildlife resulting from applications of akton have not been reported in the literature. Available information on acute toxicity and field use of akton indicates a relatively low potential wildlife hazard.

Aldicarb

CAS #116-06-3

Toxicity Class: I **Use Class:** III. Restricted

Chemical Name: 2-Methyl-2-(methylthio)propionaldehyde *O*-(methylcarbamoyl)oxime

Common and Trade Names: Temik, Ambush

Action: Insecticide, acaricide, nematicide

Properties: A white to colorless crystalline solid, miscible with most organic solvents and soluble in water at 6,000 mg/L. It is not stable under concentrated alkali conditions.

Field Applications and Formulations: Aldicarb is a systemic carbamate insecticide also effective against mites and nematodes. It is applied to soil as a seed furrow, broadcast, or band treatment and is most effective when followed by watering. The major use crops are potatoes and cotton. Aldicarb is formulated only in granules (10 and 15%) for safe handling.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	A	tech	0.8	(0.6–1.0)	80
	F	A	tech	0.65	(0.50–0.85)	80
California quail	M	10	95	2.58	(1.96–3.40)	131
European starling	U	U		4.22		228
Japanese quail	U	U		4.22		228
Mallard	M	3–4	95	3.40	(2.7–4.3)	130
Northern bobwhite	M/F	A	tech	2.0	(1.4–2.9)	121
	M/F	A	15G	2.5	(1.6–4.0)	121
Red-winged blackbird	U	U		1.78		228
Ring-necked pheasant	F	3–4	95	5.34	(3.85–7.40)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	tech	>5.0			11
Rat	M	A	tech	3		(2.3–3.8)[a]	80
	F	A	tech	2.5		(2.1–2.9)[a]	80
Japanese quail	U	0.50	99		387	(336–445)	122
Mallard	U	0.30	99		<1,000	70% mortality at 1,000 ppm	124
	U	0.15	99		594	(507–695)	124
	M	11	95	60.0		(30.0–120)[a]	130
Ring-necked pheasant	U	0.30	99		>300	No mortality to 300 ppm	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Aldicarb (10G) was applied to sugar beets in the seed furrow at a rate of 1.1 kg/ha (1 lb/acre) during a field test to investigate potential environmental hazards. Both birds and mammals were exposed to aldicarb, as confirmed by chemical analyses, and one red-legged partridge died from ingesting granules. The study concluded that the greatest hazard to wildlife was the possibility of ingesting nonincorporated granules, and ingestion of contaminated earthworms posed a secondary hazard to birds (Bunyan et al. 1981).

An investigation of aldicarb use in Great Britain reported a total of seven incidences of bird mortality from 1975 to 1976 involving anywhere from 3 to about 100 birds each. These die-offs involved several species and were largely attributed to the ingestion of granules exposed on the soil surface (Pest Infestation Control Laboratory 1978).

Persistence and Hazard Evaluation: Aldicarb is a systemic pesticide applied to the soil for control of nematodes, insects, and mites. Applied to soil, half-lives of the parent compound range from 1 to 28 weeks (Coppedge et al. 1977; Food and Drug Administration 1982), and it is degraded rapidly in pond water. Two toxicologically important metabolites are aldicarb sulfoxide and sulfone, which are usually more stable than the parent compound (Food and Drug Administration 1982). The bioconcentration potential of aldicarb, predicted from its water solubility, is low.

Comparison of acute oral LD50's for rats indicates that aldicarb is the most toxic of the carbamate and organophosphate pesticides. Both oral and dermal LD50's are extremely low, and the parent compound, sulfoxide, and the sulfone metabolites are potent cholinesterase inhibitors. Available information suggests that the carcinogenic and teratogenic potential of aldicarb may be relatively low. Aldicarb has high systemic activity and is readily translocated from plant roots to foliage. Despite its extreme acute toxicity, systemic activity, anticholinesterase metabolites, and moderately high use, aldicarb has been identified as the causative agent in relatively few wildlife die-offs. However, it is apparent that there is potential for this chemical to cause wildlife mortality, and birds have been killed by ingesting nonincorporated granules. Complete incorporation of granules into the soil is important to reduce wildlife exposure to this highly toxic pesticide.

Aldoxycarb

CAS #1646-88-4

Toxicity Class: I **Use Class:** VI

Chemical Name: 2-Methyl-2-(methylsulfonyl)propionaldehyde *O*-(methylcarbamoyl)oxime

Action: Nematicide, insecticide

Common and Trade Names: Aldicarb Sulfone, Standak

Properties: A colorless crystalline solid, stable to light and heat, but not alkali, and soluble in water at 9,000 mg/L.

Field Applications and Formulations: Aldoxycarb is a carbamate nematicide and systemic insecticide. It is applied to soil as a broadcast or band treatment, used in transplant water as a seed treatment, and is applied as a foliar spray (Berg 1982). Aldoxycarb is formulated as granules (5%) and a wettable powder (75%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	tech	26.0		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	1,000			146
Rat	U	U	tech	1,000			11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Aldoxycarb production has been discontinued by the manufacturer (Berg 1982). It was reported to be experimentally used on several crops; however, field-use data showed no significant acre-treatment use in the United States from 1978 to 1982. It is absorbed by roots, translocated through the plant, and has a residual activity of about 4–8 weeks (Thomson 1982). Its high water solubility suggests a low potential for bioconcentration.

Aldoxycarb is extremely toxic to rats (acute oral exposure) and has slight dermal toxicity to rats and rabbits. Data are sparse concerning its chronic toxicity to mammals and its overall toxicity to birds. Because information on the environmental fate and persistence of aldoxycarb is not available, its potential environmental hazard to wildlife is unknown. Current negligible field use suggests a low exposure to wildlife.

Aminocarb

CAS #2032-59-9

Toxicity Class: I **Use Class:** VI

Chemical Name: 4-(Dimethylamino)-*m*-tolyl methylcarbamate

Common and Trade Names: Matacil, Metacil

Action: Insecticide

Properties: Colorless to tan crystals, soluble in most polar organic solvents and only slightly soluble in water.

Field Applications and Formulations: Aminocarb is a contact and stomach poison carbamate insecticide used to control Lepidoptera. It has been used in Canada for spruce budworm control and is being used experimentally on orchards and citrus (Thomson 1982). It is formulated as an oil-soluble concentrate and as wettable powders (50 and 75%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mule deer	M	13–15	97	7.5–15.0		131
Rat	M	A	tech	40	(29–56)	80
	F	A	tech	38	(33–44)	80
	U	U	tech	30		11
European starling	U	U	U	212		225
Mallard	M	8	97	22.5	(17.8–28.3)	131
Red-winged blackbird	U	U	U	50	(28–89)	225
Ring-necked pheasant	M	3–4	97	42.4	(33.7–53.4)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	tech	275			11
Rat	M	A	tech	280		(257–305)[a]	80
	F	A	tech	320		(269–381)[a]	80
Japanese quail	U	0.5	99		2,325	(1,947–3,020)	122
Mallard	U	0.3	tech		2,552	(1,698–3,855)	124
Ring-necked pheasant	U	0.3	tech		>2,000	No mortality to 2,000 ppm	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Aerial applications of aminocarb at rates up to 105 g AI/ha (1.5 oz/acre) sprayed over large blocks of forest had little or no effect on most forest songbirds. Some bird populations have been reportedly reduced following spraying, without evidence of direct mortality (Buckner et al. 1975; Germain and Morin 1979). Two aerial applications of aminocarb, at 70 g AI/ha (1 oz/acre), had no significant effects on songbird brain cholinesterase activity (Busby et al. 1982).

Persistence and Hazard Evaluation: Aminocarb is registered in Canada for the control of spruce budworms (Berg 1982). Although it is not currently sold in the United States, it is being used experimentally on orchards and citrus (Thomson 1982) and field-use data show little or no current use. Applied to forests at 70 g AI/ha (1 oz/acre), aminocarb residues have been reported to degrade rapidly and have low environmental persistence (Sundaram et al. 1976).

Aminocarb has high to extreme acute oral toxicity to mammals and birds. It has moderate dermal toxicity to laboratory mammals, and its subacute dietary toxicity to birds is moderately low. Although acutely toxic, aminocarb applications at rates up to 106 g AI/ha (1.5 oz/acre) have not been reported to cause direct bird mortality.

Aspon

CAS #3244-90-4

Toxicity Class: III

Use Class: Not applicable

Chemical Name: Tetrapropyl thiopyrophosphate ($[(H_7C_3O)_2P(S)]_2O$)

Common and Trade Names: NPD

Action: Insecticide

Properties: The technical product is an amber-colored liquid, miscible with most organic solvents and soluble in water at 1,600 mg/L.

Field Applications and Formulations: Aspon is an organophosphorus contact and stomach poison insecticide used on lawns and turf to control chinch bugs (Berg 1982; Thomson 1982). It has negligible agricultural field use and is formulated as an emulsifiable concentrate (6EC) and as granules (5%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	2,710–5,010		11
	M	U	6EC	1,440–2,820		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	1,838			285
Rat	U	U	U			90-day feeding trials showed red blood cell (RBC) ChE depression at sublethal doses	285
Japanese quail	U	0.5	95		>5,000	No signs of toxicity to 5,000 ppm	122
Mallard	U	0.3	95		>5,000	No mortality to 5,000 ppm	124
Ring-necked pheasant	U	0.3	95		>5,000	No mortality to 5,000 ppm	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Aspon is a contact and stomach-poison insecticide used on turf, with little or no agricultural use. It has long residual effectiveness (Thomson 1982), and its predicted bioconcentration factor is low. However, information on its environmental fate is not available.

Although toxicity data for aspon are available for few wildlife species, its avian and mammalian toxicity seems to be relatively low. Dietary subacute studies, involving young birds, resulted in no mortality up to 5,000 ppm in the diet (Hill et al. 1975). There have been no published reports of adverse effects on wildlife resulting from the application of aspon. It is likely that wildlife exposure to aspon is minimal, and its overall toxicity to wildlife appears to be moderately low.

Azinphos-methyl

CAS #86-50-0

Toxicity Class: I

Use Class: II. Restricted

Chemical Name: *O,O*-Dimethyl hydrogen phosphorodithioate, *S*-ester with 3-(mercaptomethyl)-1,2,3-benzotriazin-4(3*H*)-one

Common and Trade Names: Bay 17147, Bay R 1582, Carfene, Cotnion-methyl, Gusathion, Guthion, Methyl Guthion

Action: Insecticide, acaricide

Properties: The technical product is a crystalline colorless solid, soluble in water at 29 mg/L. It is soluble in most organic solvents and is hydrolyzed under cold alkaline or acidic conditions (Worthing 1979).

Field Applications and Formulations: Azinphos-methyl is an organophosphorus insecticide applied to a large variety of crops to control biting and sucking insects. Cotton and apples are the major use crops, and other important crops include potatoes, cherries, and pears. It is formulated as dust (5%), an emulsifiable concentrate (2EC), granules (10%), wettable powders (25 and 50%), and it is also used in combination with parathion.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	U	U	U	80		285
Mule deer	M	15–16	90	32.0–64.0		131
Rat	M	A	tech	13		80
	F	A	tech	11		80
	F	U	U	16.4		285
	U	U	tech	5–20		11
Chukar	M	3–4	90	84.2	(53.0–134)	131
European starling	U	U	U	27	(15–48)	225
Mallard	M	3–4	90	136	(97.8–188)	131
Northern bobwhite	M	24	90	60.0–120		131
Red-winged blackbird	U	U	U	8.5		225
Ring-necked pheasant	M	3–5	90	74.9	(59.5–94.3)	131
	M	3–4	0.240 kg/L (2 lb/gal)	283	(200–400)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	220			
	U	U	U			No effect at dietary level of 5 ppm at 90 days and 2.5 ppm at 2 years	146, 285
Japanese quail	U	0.5	92		637	(515–788)	122
	F	I	U			Dietary level of 540 ppm for 10 weeks affected growth and reduced egg production; 1,620 ppm killed all birds	94
Mallard	U	0.3	92		1,940	(978–4,506)	124
Northern bobwhite	U	0.5	92		488	(394–601)	124
	F	I	U			Dietary level of 20 ppm reduced growth; 80% mortality at 540 ppm; all killed at 1,620 ppm	94
Ring-necked pheasant	U	0.7	92		1,821	(1,355–2,468)	124

Effects of Field Applications and Field Tests on Wildlife: Young, penned ring-necked pheasants were exposed to formulated azinphos-methyl at 1.1 and 5.7 kg/ha (1 and 5 lb/acre) five times at 2-week intervals. No mortality of the 84 birds exposed was observed (Zorb and Black 1965). This experiment was repeated using a 11.3-kg/ha (10-lb/acre) treatment twice, 2 weeks apart, and results again showed no mortality or visibly poisoned birds (Zorb and Black 1965).

Persistence and Hazard Evaluation: Azinphos-methyl is a nonsystemic insecticide and acaricide with long persistence and residual activity of up to 3 weeks (Thomson 1982). It is least persistent when applied to the soil surface as an emulsifiable concentrate (50% loss at 12 days) and more persistent in the granular form when incorporated into the soil (50% loss at 28 days) (Schulz et al. 1970). One year following soil treatment at 5.7 kg/ha (5 lb/acre), 13% of the original amount was recovered as the parent compound and derivatives (Schulz et al. 1970). The half-life for azinphos-methyl applied to apples was 2.6–6.3 days (Pree et al. 1976); on lemons and oranges it was about 38 and 355 days, respectively (Gunther 1969). Applied at 5.7 kg/ha (5 lb/acre), traces of azinphos-methyl, still toxic to insects, were present after 2 years (Schulz et al. 1970). Although this insecticide has a low predicted bioconcentration factor, it has been demonstrated to be relatively persistent, especially when applied in a granular formulation.

Azinphos-methyl can be extremely toxic to mammals and birds and is available in formulations with a high percentage of active ingredient. The compound is highly reactive with cholinesterase and has low dephosphorylation rates. Although azinphos-methyl is highly toxic and apparently has a relatively long environmental persistence, there have been no published reports of azinphos-methyl (applied exclusively without other pesticides) as the causative agent of any wildlife die-off. The potential for this pesticide to cause wildlife problems has either not been realized under field conditions or has gone largely undetected or unreported.

Bendiocarb

CAS #22781-23-3

Toxicity Class: I **Use Class:** VI

Chemical Name: 2,3-(Isopropylidenedioxy)phenyl methylcarbamate

Common and Trade Names: Ficam, Garvox, Multamat, Niomil, Seedox, Tattoo, Turcam

Action: Insecticide

Properties: A white crystalline solid stable to hydrolysis in water and soluble in water at 40 mg/L.

Field Applications and Formulations: Bendiocarb is a broad spectrum carbamate insecticide with contact and stomach-poison activity. It is used to control household and structural pests and is also used on turf and ornamentals. It is being used experimentally on corn to control rootworms and other pests and for mosquito control in Texas (Berg 1982). Bendiocarb is formulated as a dust (1%), in granules (2.5, 5, and 10%), oil suspension ULV (25%), and as a wettable powder (76%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	40–120		11
	U	U	76WP	179		11
Northern bobwhite	M/F	A	tech	21	(17–26)	121
	M/F	A	10G	33	(24–44)	121

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	566–600			146

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Bendiocarb is a broad-spectrum insecticide, primarily used in nonfield applications, with current experimental use as a soil insecticide (Berg 1982; Thomson 1982). It decomposes rapidly in soils and on foliage (Cronin 1977), and its predicted environmental bioconcentration potential is low.

Bendiocarb is of high acute oral toxicity and moderate dermal toxicity to laboratory rats; however, few avian toxicological data are available. Both the technical grade and granular formulation were highly toxic to northern bobwhite quail (Hill and Camardese 1984). Bendiocarb is highly toxic to bees and fish (Thomson 1982). Currently, low field use indicates that exposure to wildlife is probably minimal. Toxicological data gaps exist for potential sublethal effects of bendiocarb; however, it has been reported to be a rapidly reversible cholinesterase inhibitor. Bendiocarb's overall hazard to wildlife cannot be well defined due to the paucity of toxicological and environmental fate information. However, current minimal field use suggests a low probability of wildlife exposure.

Bomyl

CAS #122-10-1

Toxicity Class: I **Use Class:** Not applicable

Chemical Name: Dimethyl 3-hydroxyglutaconate, dimethyl phosphate

Common and Trade Names: Fly Bait Grits, Swat

Action: Insecticide

Properties: The technical product is a liquid soluble in most organic solvents and practically insoluble in water.

Field Applications and Formulations: Bomyl is an organophosphorus insecticide used as a fly bait with agricultural and other applications. Some experimental field applications have been made on cotton. It is formulated as an emulsifiable concentrate (50%), fly bait (1%), and as a technical liquid (80 and 90%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	31		11
European starling	U	U	U	9.5	(3.0–30.0)	225
Red-winged blackbird	U	U	U	0.95	(0.3–3.0)	225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	20–31			146

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Bomyl is used as a bait for flies around livestock, poultry, and other areas where fly control is needed. It has also been applied experimentally under field conditions; however, information on the environmental fate and persistence of bomyl is not available. Bomyl is extremely toxic (acute oral exposure) to the laboratory rat, as well as to starlings and blackbirds. Dermal tests with rabbits indicate extreme acute dermal toxicity (Kenaga and Morgan 1978). The lack of current field use of bomyl probably minimizes wildlife exposure, and wildlife incidences involving bomyl have not been reported. Its apparent high toxicity should be considered prior to application.

Bromophos

CAS #2104-96-3

Toxicity Class: IV **Use Class:** Not applicable

Chemical Name: *O*-(4-Bromo-2,5-dichlorophenyl) *O,O*-dimethyl phosphorothioate

Common and Trade Names: Brofene, Brophene, Netal, Nexion

Action: Insecticide, acaricide

Properties: Yellowish crystals, soluble in most organic solvents and in water at 40 mg/L.

Field Applications and Formulations: Bromophos is an organophosphorus stomach-poison and contact insecticide and acaricide used on turf in the United States and on a variety of crops outside the United States (Thomson 1982). Bromophos is formulated in aerosols, dust (2%), emulsifiable concentrates (2 and 4EC), granules (5%), as a seed dressing, and in wettable powders (25 and 40%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	2,829–5,850		285
Rabbit	U	U	U	720		285
Rat	M	A	tech	1,600	(1,322–1,936)	80
	F	A	tech	1,730	(1,373–2,180)	80
Chicken	F	U	U	9,700		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			No clinical symptoms observed in a 2-year feeding study at 44 mg/kg per day	285
Rabbit	U	U	U	2,181			285
Rat	M	A	tech	>5,000			80
	F	A	tech	>5,000			80
	U	U	U			No clinical symptoms observed in a 2-year feeding study at 350 mg/kg per day	285

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Bromophos is a nonsystemic contact and stomach-poison insecticide and acaricide used on turf in the United States to control chinch bugs (Thomson 1982). Outside the United States, it is used on a variety of crops and for mosquito control. Bromophos is a relatively persistent organophosphorus insecticide (Eto 1974). Because of its lipophilic properties, it penetrates the waxy surface of fruits, which delays decomposition (Eichler 1972). Although residues in certain soils have been found to persist beyond 26 weeks, half-lives for residues in and on crops appear to be generally less than 1 month. The only anticholinesterase metabolite of bromophos is bromoxon (Schimmel et al. 1979).

Bromophos has moderately low mammalian and avian toxicity for laboratory species; however, its toxicity to wildlife species has not been reported. Available data indicate low toxicity to laboratory animals through both oral and dermal routes of exposure. Bromophos may potentiate the toxicity of several cholinesterase-inhibiting pesticides (Vettorazzi 1976), and more information regarding its interactions with other pesticides is needed to assess its potential environmental hazard. Bromophos has not been reported as a suspected causative agent in wildlife die-offs.

Bufencarb

CAS #8065-36-9

Toxicity Class: II **Use Class:** VI

Chemical Name: 3-(1-Ethylpropyl)phenyl methylcarbamate, mixture with 3-(1-methylbutyl)phenyl methylcarbamate

Common and Trade Names: Bux

Action: Insecticide

Properties: The technical product is a yellow to amber solid, soluble in water at less than 50 mg/L. It is stable under neutral to acidic conditions.

Field Applications and Formulations: Bufencarb is a soil and foliage carbamate insecticide used to control corn rootworm, rice water weevil larvae, and other insects. Most applications are on rice, with lesser use on corn. As a soil treatment, it is applied at planting or at cultivation. Bufencarb is formulated as an emulsifiable concentrate (0.240 kg/L; 2 lb/gal) and in granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	170		11
	U	U	U	87		150
Mallard	F	3–4	68.9	10.5	(8.84–12.5)[a]	131
Ring-necked pheasant	M	3	68.9	88.0	(61.6–126)	131

[a]Range from the highest dose producing no mortality to the lowest dose producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	400			146
	U	U	U	680			150
Japanese quail	U	0.5	tech		>5,000	42% mortality at 5,000 ppm	122, 124
Mallard	U	0.3	tech		>5,000	38% mortality at 5,000 ppm	124
Ring-necked pheasant	U	0.3	tech		>5,000	No mortality at 5,000 ppm	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Bufencarb was formerly a high-volume-use methylcarbamate insecticide (Kuhr and Dorough 1976). Although production of bufencarb ended in 1975, continued low use suggests remaining quantities are still being applied (Food and Drug Administration 1982). Bufencarb degrades through hydrolysis, and surface residues on rice decompose rapidly (Food and Drug Administration 1982). Degradation rates are especially sensitive to changes in pH, and alkaline conditions accelerate hydrolysis. Half-lives in soils range from 1 to 4 weeks under aerobic conditions, and from 2 to 6 weeks under anaerobic conditions (Food and Drug Administration 1982). Hydroxylated metabolites are less toxic than the parent compound but also have anticholinesterase activity (Food and Drug Administration 1982). Bufencarb is rapidly metabolized in animals, and its predicted bioconcentration potential is low.

Bufencarb has moderate to high acute oral toxicity to rats and some bird species and is of low subacute dietary toxicity to the bird species tested. Certain studies of the potential chronic effects of bufencarb have been judged invalid by the EPA (Food and Drug Administration 1982). Its acute avian toxicity suggests a possible acute hazard to wild birds; however, rapid degradation in the environment and low overall field use probably minimize wildlife exposure.

Butonate

CAS #126-22-7

Toxicity Class: IV **Use Class:** Not applicable

Chemical Name: Butyric acid, ester with dimethyl (2,2,2-trichloro-1-hydroxyethyl)phosphonate

Common and Trade Names: Butilchlorofos, Tribuphon

Action: Insecticide

Properties: A liquid, moderately soluble in water and highly soluble in many organics.

Field Applications and Formulations: Butonate is an organophosphorus insecticide used to control flies, cockroaches, ants, and ectoparasites of domestic animals (Eto 1974).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	1,100–1,600		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	7,000			11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Production of butonate has been discontinued by the manufacturer (Berg 1982). It is used to control household pests and ectoparasites of domestic animals. Data on its environmental fate and persistence are lacking. Toxicological tests with rats suggest low mammalian toxicity; however, its avian toxicity is unknown. In plants and insects, butonate is enzymatically converted to trichlorfon, a more acutely toxic organophosphate (Eto 1974). The probability of wildlife exposure to butonate is low due to nonfield applications and the discontinuation of production.

Carbaryl

CAS #63-25-2

Toxicity Class: III **Use Class:** II

Chemical Name: 1-Naphthyl methylcarbamate

Common and Trade Names: Carbamine, Carpolin, Cekubaryl, Denapon, Devicarb, Dicarbam, Hexavin, Karbaspray, Nac, Ravyon, Septene, Sevin, Tercyl, Tricarnam

Action: Insecticide

Properties: Technical carbaryl is a white crystalline solid, soluble in polar organic solvents and in water at 40 mg/L.

Field Applications and Formulations: Carbaryl is a broad-spectrum carbamate insecticide with contact and stomach-poison activity. It is widely used on a variety of crops, as well as on forests, rangeland, turf, poultry, and pets. A high percentage of its use in the United States is agricultural, with soybeans and corn being the major crops treated. Many acres of rangeland are treated with carbaryl for grasshopper control, and it is also widely used to control forest pests. Carbaryl is formulated as bait (20%), dusts (5 and 10%), flowable (0.479 kg/L; 4 lb/gal), granules (5 and 10%), and wettable powders (50 and 80%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mule deer	F	11	95	200–400		131
Rabbit	U	U	U	710		146
Rat	M	A	tech	850		80
	F	A	tech	500		80
Canada goose	M/F	U	50	1,790	(1,480–2,180)	131
California quail	M	10	480 g/L	>2,000		131
Japanese quail	M	2	85	2,290	(1,740–3,020)	131
Mallard	F	3	85	>2,564		131
Red-winged blackbird	U	U	U	56	(32–100)	225
Ring-necked pheasant	M	3–4	95	>2,000		131
	F	3–4	0.479 kg/L (4 lb/gal)	707	(500–1,000)[a]	131
Rock dove	M/F	U	85	1,000–3,000		131
Sharp-tailed grouse	M/F	U	95	<1,000		131
Bullfrog	F	U	50	>4,000		131

[a]Range from the highest dosage producing no mortality to the lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	>2,000			146
Rat	M	A	tech	>4,000			80
	F	A	tech	>4,000			80
	U	U	U			90-day chronic oral "no effect" level of 200 ppm	146
Japanese quail	U	0.5	98		>10,000		122
	U	0.5	50		>10,000		122
Mallard	U	0.75	99.8		>5,000	No mortality to 5,000 ppm	124
Northern bobwhite	U	0.75	99.8		>5,000	No mortality to 5,000 ppm	124
Ring-necked pheasant	U	0.75	99.8		>5,000	No mortality to 5,000 ppm	124

Effects of Field Applications and Field Tests on Wildlife: An aerial application of carbaryl at 1.4 kg/ha (1.25 lb/acre) in fuel oil did not appear to affect the abundance, condition, and reproduction of small mammals (Connor 1960). During this same study, toads, frogs, salamanders, and snakes also appeared unaffected (Connor 1960). A ground application of 2.3 kg carbaryl/ha (2 lb/acre) did not alter genetic parameters in feral mice *(Mus musculus;* Graf et al. 1976).

A 1.1 kg/ha (1 lb/acre) aerial application of carbaryl was believed to have caused some nestling mortality in tree swallows through ingestion of poisoned insects; however, a cause–effect relation was not completely demonstrated (Bednarek and Davison 1967). Many studies have investigated possible changes in forest bird populations following the application of carbaryl. Of these studies, two have found a low occurrence of ChE-inhibited birds (DeWeese et al. 1979; Zinkl et al. 1979), and one reported a gradual decline in bird species diversity and density (Moulding 1976). Other studies have not observed detectable changes in bird numbers following applications of carbaryl (Bart 1979; DeWeese et al. 1979), and one study did not find brain ChE inhibition in birds following applications of 0.3 and 0.6 kg/ha (0.3 and 0.5 lb/acre; Gramlich 1979). A review of field tests of carbaryl applied at rates of 483 to 1,136 g/ha (6.8 to 16.0 fl oz/acre) concluded that no wildlife mortality was observed although some decreases in bird numbers did occur (McEwen 1982).

Persistence and Hazard Evaluation: Carbaryl is a broad-spectrum, widely used insecticide. The largest volume use occurs as a foliar spray applied to agricultural crops, rangeland, and forests. It is relatively nonpersistent in the environment and half-lives in soil are about 7–10 days (Von Rumker et al. 1974). Insecticidal activity does not generally persist beyond 2 weeks, although persistence is enhanced when it is applied in an oil carrier. When administered orally, carbaryl is rapidly metabolized and is not stored in tissues. It has a low predicted bioconcentration factor. Carbaryl is of low acute and chronic toxicity to most bird and mammal species tested. It is a reversible cholinesterase inhibitor, and degradation products are less toxic than the parent compound (Von Rumker et al. 1974). Numerous studies have evaluated the potential impact of carbaryl use on wildlife species, and there have been no reports of wildlife die-offs resulting from carbaryl applications. Some studies have reported decreases in bird numbers, although the actual causes, either direct or indirect, have not been established. Carbaryl is slightly toxic to fishes and highly toxic to honeybees (Von Rumker et al. 1974). Available information indicates low acute and chronic toxicity to wildlife, low environmental persistence, and no reported wildlife die-offs associated with its use.

Carbofuran

CAS #1563-66-2

Toxicity Class: I **Use Class:** I. Restricted

Chemical Name: 2,3-Dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate

Common and Trade Names: Curaterr, Furadan, Yaltox

Action: Insecticide, nematicide, acaricide

Properties: A colorless crystalline solid, soluble in water at 700 mg/L. It is unstable in alkaline media.

Field Applications and Formulations: Carbofuran is a carbamate insecticide and nematicide with systemic, contact, and stomach-poison activity. Major agricultural use of carbofuran is on corn, with relatively minor use on many other crops. It is formulated as a flowable (0.479 kg/L; 4 lb/gal) and in granules (2, 3, 5, and 10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	19		146
Rat	U	U	U	11		11

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Fulvous whistling-duck	F	3–6	98.8	0.238	(0.20–0.28)[a]	131
House sparrow	U	U	90–99	1.3		227
Mallard	M	12	98.8	0.480	(0.381–0.604)	131
	F	3–4	98.8	0.397	(0.315–0.50)	131
	F	12	98.8	0.510	(0.410–0.635)	131
Northern bobwhite	F	3	98.8	5.04	(3.64–6.99)	131
	M/F	A	tech	12	(7–19)	121
	M/F	A	10G	12	(9–16)	121
Red-winged blackbird	U	U	90–99	0.42		227
Ring-necked pheasant	F	3	98.8	4.15	(2.38–7.22)	264

[a]Range from the highest dosage producing no mortality to the lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	10,200			11
House sparrow	U	U	90–99	100			227
Japanese quail	U	0.5	99		746	(549–1,014)	122
Mallard	U	0.3	99		190	(156–230)	124
Ring-necked pheasant	U	0.3	99		573	(492–666)	124

Effects of Field Applications and Field Tests on Wildlife: Four reports of American wigeon die-offs, in published and unpublished reports, indicated carbofuran as the causative agent (Stickel 1975; Flickinger et al. 1980; Coon 1983, personal communication). One of these incidences killed 2,450 ducks in one locality where carbofuran was applied to alfalfa (Stickel 1975), and two others resulted in over 1,000 ducks dying (Flickinger et al. 1980), indicating substantial waterfowl mortality may result from the use of this chemical. Carbofuran (flowable), reportedly applied to alfalfa at the recommended rate, was determined to be the cause of a die-off involving 500 Canada geese (Flickinger et al. 1980; Hazard Evaluation–EPA 1981). Many other occurrences of waterfowl mortality, caused by applications of carbofuran, have been reported in the literature. Other species involved have included American coots, mallards, northern pintails, and green-winged teal (Flickinger et al. 1980; Hazard Evaluation–EPA 1981).

Carbofuran applied in granular (3G) formulation to rice fields at 0.6 kg/ha (0.5 lb/acre) resulted in mortality of birds, frogs, fish, crayfish, and earthworms, generally within the first 48 h after treatment (Flickinger et al. 1980).

Persistence and Hazard Evaluation: Carbofuran is a systemic insecticide and nematicide widely used on corn and other agricultural crops. It is applied to foliage and to soil in the furrow or in a band. Carbofuran is widely used and is highly effective against corn rootworm as well as foliage-feeding pests. Its major degradation products range from slightly to highly toxic (Food and Drug Administration 1982). Carbofuran is a moderately persistent carbamate insecticide, with soil half-lives ranging from 2 to 50 weeks. A laboratory bioassay demonstrated biological activity that persisted in soil up to 16 weeks (Harris 1969*b*). Degradation in alkaline soils is more rapid (Getzin 1973), and soil residues may decline more rapidly with rainfall (Gorder et al. 1982). Carbofuran applied at 1.1 kg AI/ha (1 lb/acre) resulted in maximum residues of the 3-hydroxy metabolite at 9–14 days after treatment (Shaw et al. 1969). Its bioconcentration potential, predicted from water solubility, is low.

Carbofuran is a potent cholinesterase inhibitor with extremely acute oral toxicity. Although the parent compound is a moderately persistent carbamate, its environmental metabolites are also toxic. It is toxic to bees, fish, birds, mammals, and soil insects (Von Rumker et al. 1974). There are numerous accounts of wildlife die-offs resulting from field applications of carbofuran. Available information indicates that even when applied at recommended rates, carbofuran may cause wildlife mortality. Because of its toxicity, moderate persistence, and toxic degradation products, wildlife exposure to carbofuran should be avoided.

Carbophenothion

CAS #786-19-6

Toxicity Class: I **Use Class:** V

Chemical Name: *S*-[[(*p*-Chlorophenyl)thio]methyl] *O,O*-diethyl phosphorodithioate

Common and Trade Names: Dagadip, Endyl, Garrathion, Lethox, Nephocarp, Trithion

Action: Insecticide, acaricide

Properties: A colorless to amber liquid, soluble in most organic solvents and in water at 0.34 mg/L (Kenaga 1980).

Field Applications and Formulations: Carbophenothion is a nonsystemic organophosphorus insecticide and acaricide applied to a variety of crops and livestock. Crops receiving the highest numbers of acres treated include cotton and citrus, with some use on alfalfa, corn, and wheat. Formulations include dusts (1–3%), emulsifiable concentrates (2, 4, 6, and 8EC), and wettable powder (25%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	218		146
Rat	M	A	tech	30		80
	F	A	tech	10		80
Canada goose	U	U	95	29–35		135
European starling	U	U	U	5.6	(3.2–10.0)	225
Japanese quail	U	U	95	56.8	(50.8–63.6)	135
Mallard	F	3–4	94.65	121	(95.9–152)	264
Red-winged blackbird	U	U	U	7.5		225
Ring-necked pheasant	M	3–4	94.65	269	(194–373)	131
Rock dove	U	U	95	34.8	(31.1–38.9)	135
Sharp-tailed grouse	M	A	94.65	75.6–170		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	1,270			285
Rat	M	A	tech	54			80
	F	A	tech	27			80
	U	U	U			"No effect" chronic dietary level of 5 ppm at 90 days	146

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Japanese quail	U	0.5	95		4,434	(2,492–7,887)	122

Effects of Field Applications and Field Tests on Wildlife: An estimated 500 greylag geese died over a period of about 1 week in an area where winter wheat seed was treated with carbophenothion and a mercurial fungicide. Carbophenothion and wheat were found in bird crops and gizzards, and brain cholinesterase activity approached 90% inhibition (Bailey et al. 1972).

A series of incidences, resulting in the deaths of approximately 450 greylag and 240 pink-footed geese, were related to carbophenothion poisoning. Ingestion of carbophenothion-treated winter wheat seed was determined to be the cause of death, which was confirmed through residue and enzyme analyses (Hamilton et al. 1976). These incidences occurred in Scotland, where carbophenothion has now been withdrawn from use as a seed treatment (Stanley and St. Joseph 1979).

Persistence and Hazard Evaluation: Carbophenothion is a nonsystemic insecticide and acaricide that has relatively long residual activity and persistence. It has been found to persist in soils for longer than 6 months (Mulla et al. 1961). Residues of carbophenothion on vegetables were determined to consist of the parent compound, sulfoxide, and to a lesser extent the sulfone and corresponding oxygen analogs (Eto 1974; Vettorazzi 1976). The parent compound, and its environmental metabolites, have anticholinesterase activity (Food and Drug Administration 1982). The predicted bioconcentration factor for carbophenothion exceeds 1,000 and is one of the highest of the organophosphates (Kenaga 1980). Its high bioconcentration factor may be related to the chlorinated phenyl similar to those groups found in the structure of organochlorines.

Carbophenothion is highly toxic to most of the laboratory and wildlife species in which it has been tested. Reproductive effects have been demonstrated in studies with rats; however, teratogenic effects have not been observed (Food and Drug Administration 1982). Carbophenothion was not neurotoxic to hens fed up to 100 mg/kg (Food and Drug Administration 1982). There is considerable variation in acute toxicity among some species tested; however, there is substantial evidence that carbophenothion is extremely toxic to geese and many other bird species. Avian die-offs in Scotland implicated carbophenothion-treated wheat seed in many incidences of goose mortality (Bailey et al. 1972; Hamilton et al. 1976; Stanley and St. Joseph 1979). Similar reports of avian die-offs do not exist for the United States. The relatively long persistence, potential bioconcentration, and relatively high acute toxicity of carbophenothion indicate that the use of this chemical should be carefully evaluated to avoid wildlife exposure.

Chlorfenvinphos

CAS #470-90-6

Toxicity Class: I

Use Class: Not applicable. Restricted

Chemical Name: 2-Chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate

Common and Trade Names: Birlane, Sapecron, Steladone, Supona, Unitox, Vinylphate

Action: Insecticide, acaricide

Properties: The technical product is an amber-colored liquid, miscible with most organic solvents and soluble in water at 145 mg/L.

Field Applications and Formulations: Chlorfenvinphos is an organophosphorus soil insecticide also used as a livestock dip or spray, a seed treatment, and as a foliar insecticide. In the United States it is registered for use on agricultural premises and equipment and to control insects for veterinary purposes (Food and Drug Administration 1982). Formulations include dust (5%), emulsifiable concentrate (2EC), granules (10%), and wettable powder (25%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	>12,000		285
Mouse	U	U	U	117-200		285
Rabbit	U	U	U	300-1,000		285
Rat	M	A	tech	15	(11-19)	80
	F	A	tech	13	(11-15)	80
	U	U	tech	10-39		11
Mallard	F	3-4	91 and 8[a]	85.5	(44.5-164)	131
Northern bobwhite	M	12	91 and 8[a]	80.0-160		131
Ring-necked pheasant	F	3-4	91 and 8[a]	63.5	(45.8-88.1)	131

[a]91% *B*-isomer, 8% *a*-isomer.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	417-4,700			285
Rat	M	A	tech	31		(27-34)[a]	80
	F	A	tech	30		(25-36)[a]	80
	U	U	U			2-year feeding trial showed no adverse effects on growth or food consumption at 10 ppm	285

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Chlorfenvinphos is a nonsystemic insecticide and acaricide with contact activity. Between 3 and 15% of the initial amounts remained in soil 15 weeks following an application in sandy soil, and about 70% remained in peaty soil after 12 months (Williams 1975). Applied to soil at 5.7 kg AI/ha (5 lb/acre), chlorfenvinphos residues declined about 73% during the 23-week growing season, and detectable levels were found in trees 4 years after application (Chisholm 1975). The overall persistence of this chemical is relatively long; however, its bioconcentration potential, predicted from water solubility, is low.

Chlorfenvinphos is highly toxic to rats, which may be attributed to the poor degradative activity of the liver microsomal enzymes in this species (Eto 1974). It is of moderate to low toxicity to other mammals and of high toxicity to wild bird species (Tucker and Crabtree 1970; Hudson et al. 1984). It is embryotoxic in some species (Dzierzawski and Minta 1979) and has demonstrated mutagenic potential in some tests (Food and Drug Administration 1982). There have been no reports of adverse effects on wildlife associated with the use of chlorfenvinphos. Because of low-volume usage (Food and Drug Administration 1982) and the nonfield applications of this chemical, it is likely that wildlife exposure, at least in the United States, is minimal. Current registered uses for this product minimize the overall potential hazard of chlorfenvinphos to wildlife.

Chlorpyrifos

CAS #2921-88-2

Toxicity Class: II **Use Class:** III. Restricted

Chemical Name: *O,O*-Diethyl *O*-(3,5,6-trichloro-2-pyridyl) phosphorothioate

Common and Trade Names: Brodan, Dowco 179, Dursban, Eradex, Killmaster, Lorsban, Pyrinex

Action: Insecticide

Properties: White granular crystals, soluble in water at 0.3 mg/L.

Field Applications and Formulations: Chlorpyrifos is a nonsystemic organophosphorus insecticide used to control ants, aphids, rootworms, cutworms, termites, adult and larval mosquitos, and many other pest species. Application rates range from 0.1 to 5.7 kg actual/ha (0.1 to 5 lb/acre; Thomson 1982). The primary use crop is corn; however, many acres are treated in mosquito-abatement programs. It is available in emulsifiable concentrates (2 and 4EC), granules (15%), wettable powder (25%), and household spray (0.5%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic goat	F	U	94.5	500–1,000		131
Guinea pig	U	U	U	500		11
Rabbit	U	U	U	1,000–2,000		146
	U	U	U	2,000		11
Rat	U	U	U	97–276		11
California quail	F	5–7	94.5	68.3	(40.7–115)	131
Canada goose	M/F	U	99	40–80		131
Chukar	M	3–5	99	61.1	(47.5–78.6)	131
	F	3–5	99	60.7	(43.8–84.1)	131
House sparrow	M	U	94.5	21.0	(5.59–79.1)	131
Japanese quail	M	2.5	94.5	15.9	(10.5–24.0)	131
Mallard	F	U	99	75.6	(35.4–161)	131
	M/F	0.6	99	112	(11.5–1,089)	131
Northern bobwhite	M/F	A	tech	32	(24–43)	121
	M/F	A	15G	108	(80–145)	121
Ring-necked pheasant	M	4–12	94.5	8.41	(2.77–25.5)	131
	F	3–5	94.5	17.7		131
Rock dove	M/F	U	94.5	26.9	(19.0–38.1)	131
Sandhill crane	M	U	94.5/99	25–50		264
Bullfrog	M	U	94.5	>400		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			Chronic oral 0.01 ppm per day with "no effect" at 90 days	146
Rabbit	U	U	U	>2,000			11

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	202		Chronic oral 0.03 ppm per day with "no effect" at 90 days	146
Japanese	U	0.5	97		293	(112–767)	122
quail	U	0.5	41		492	(351–680)	122
Mallard	U	0.3	97		940		124
Ring-necked pheasant	U	0.3	97		553	(421–687)	124

Effects of Field Applications and Field Tests on Wildlife: Mallard ducklings were exposed to chlorpyrifos by hand spray applied four times, at 2-week intervals, at 0.01–1.1 kg/ha (0.01–1 lb/acre). No mortality was observed for control birds; however, 14 of 33 treatment ducklings died. Mortality rates did not differ between application rates (Hurlbert et al. 1970). In another study, confined chicks aerially sprayed at 0.1 kg/ha (0.1 lb/acre) did not have significant depression of brain or plasma cholinesterase (Kenaga 1974). Birds confined to ground areas were not killed by the application of 4.5–36.2 kg/ha (4 to 32 lb/acre; Kenaga 1974).

There have been two reports of geese found dead on golf courses treated with chlorpyrifos alone or in combination with diazinon. One incident involved 8 geese and in the other 35 birds were killed. Information on application procedures was not available (Hazard Evaluation–EPA 1981).

Persistence and Hazard Evaluation: Chlorphyrifos is a nonsystemic insecticide applied at rates ranging from 0.01 kg AI/ha (0.0125 lb/acre) for mosquito control to 4.5 kg AI/ha (4 lb/acre) for grub control on turf. It is considered to be of low to moderate environmental persistence, although when applied to soil, polluted water, and buildings it may retain its activity for several weeks (Thomson 1982).

In a review of chlorpyrifos residues in plants, it was concluded that application rates up to 1.1 kg AI/ha (1 lb/acre) did not result in residues exceeding 28 mg/kg (Kenaga 1974). Half-lives of residues were about 1–2 days (Kenaga 1974). Where chlorpyrifos was applied at 1.1 kg AI/ha (1 lb/acre) to corn and bermuda grass, residues were determined to be less than 1 mg/kg after 21 days (Leuck et al. 1968). When the chemical was applied to turf at 2.3 kg AI/ha (2 lb/acre) in a granular formulation, residues in soil and grass remained above 1 mg/kg after 6 weeks (Kuhr and Tashiro 1978). Muck soils treated at this same rate retained more than 1 mg/kg chlorpyrifos for 16 weeks (Davis and Kuhr 1976). The predicted bioconcentration factor for chlorpyrifos (flowing-water system) exceeds 1,000 and warrants further evaluation for hazard assessment (Kenaga 1980).

Chlorpyrifos is of moderate to slight mammalian toxicity. It is readily absorbed by mammals, and the primary metabolite is of relatively low mammalian toxicity (Vettorazzi 1976). It is highly toxic to several bird species via acute oral exposure; however, its subacute toxicity to young birds during 5-day dietary tests placed it in the moderately toxic category (Hill et al. 1975). When applied at 0.03 kg AI/ha (0.025 lb/acre) for mosquito control, adverse effects were not reported for birds, fish, shrimp, or crabs; but at 0.06 kg AI/ha (0.05 lb/acre) some mortality among small fish, and a reduction in numbers of brown shrimp, was observed (Ludwig et al. 1968). Chlorpyrifos is considered to be toxic to fish, crustaceans, and bees (Thomson 1982).

Available data indicate that wildlife die-offs have not been associated with applications of chlorpyrifos at or below recommended rates. However, further studies on field exposure and wildlife hazards are indicated.

Coumaphos

CAS #56-72-4

Toxicity Class: I **Use Class:** Not applicable

Chemical Name: 3-Chloro-7-hydroxy-4-methylcoumarin, *O*-ester with *O,O*-diethyl phosphorothioate

Common and Trade Names: Ag:idip, Asuntol, Baymix, Co-Ral, Diolice, Meldane, Muscatox, Resistox, Resitox, Umbethion

Action: Livestock insecticide

Properties: A tan to colorless crystalline solid nearly insoluble in water at 1.5 mg/L and soluble in many aromatics.

Field Applications and Formulations: Coumaphos is an organophosphorus insecticide used to control a variety of livestock insects and ectoparasites. It is available in crumbles (0.32%), dusts (1 and 5%), an emulsifiable concentrate (1EC), feed premix (2 and 11.2%), pour-on (4%), spray foam (3%), and a wettable powder (25%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	55		63
Rat	M	A	tech	41	(34–50)	80
	F	A	tech	16	(14–17)	80
European starling	U	U	U	32		225
Mallard	M	3–4	95	29.8	(21.5–41.3)	131
Red-winged blackbird	U	U	U	3.5		225
Ring-necked pheasant	F	3–4	95	7.9	(5.7–11.0)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	A	tech	860			80
Japanese quail	U	0.5	95		222	(158–312)	122
Mallard	U	0.3	95		709	(521–1,032)	124
Northern bobwhite	U	0.5	95		120	(104–139)	124
Ring-necked pheasant	U	0.5	95		318	(277–364)	124

Effects of Field Applications and Field Tests on Wildlife: Coumaphos was determined to be the causative agent in a waterfowl die-off involving more than 220 American wigeons found dead at ponds adjacent to a feedlot (Coon 1983, personal communication). Laboratory analyses of these specimens confirmed coumaphos residues in the gastrointestinal tracts, and brain ChE was inhibited 60 to 85% in the 6 birds examined (Coon 1983, personal communication).

Persistence and Hazard Evaluation: Coumaphos is a systemic livestock insecticide used on a wide variety of animals for the control of many insect pests. It has both contact and systemic activity and is applied both orally and dermally. It is highly toxic to birds through acute oral exposure, moderately toxic through dietary exposure (Hill and Camardese 1986), and has high acute oral toxicity to laboratory mammals. The use of coumaphos in animal feed provides potential dietary exposure to wildlife that have access to treated feed. Coumaphos has high toxicity to wildlife species and evaluation of the potential for wildlife exposure should be made prior to the use of this chemical.

Crotoxyphos

CAS #7700-17-6

Toxicity Class: II **Use Class:** Not applicable

Chemical Name: α-Methylbenzyl (*E*)-3-hydroxycrotonate, dimethyl phosphate

Common and Trade Names: Ciodrin, Ciovap, Cypona, Cypona E.C., Duo-kill

Action: Insecticide

Properties: A straw-colored liquid, soluble in water at 1,000 mg/L.

Field Applications and Formulations: Crotoxyphos is an organophosphorus insecticide applied to livestock and agricultural premises to control flies, lice, ticks, and mites. It is not applied to crops or forests. Crotoxyphos is formulated in dusts, emulsifiable concentrates (2, 3, and 4EC), solution (2%), and wettable powder. It is also available in a mixture with DDVP.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	90		285
Rat	M	A	tech	110	(95–128)	80
	F	A	tech	74	(65–84)	80
Mallard	M	3–4	85	790	(411–1,520)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	385			11
Rat	M	A	tech	375		(323–435)[a]	80
	F	A	tech	202		(177–230)[a]	80
	M/F	U	U			90-day feeding trial with no histopathological or growth effects at 900 ppm fed to males and 300 ppm fed to females	285
Japanese quail	U	0.5	25 + xylene		520	(429–631)	122

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Crotoxyphos is a livestock insecticide most often applied to cattle and pigs and also used to control insects on agricultural premises. It has rapid action and exhibits moderate residual activity. It has moderately acute toxicity to the test species given above, and it is toxic to fish (Thomson 1982). Crotoxyphos has not been reported as the causative agent in any wildlife die-offs. Its limited use as a nonsystemic livestock insecticide and its moderate toxicity indicate a relatively low potential for exposure of wildlife species.

Crufomate

CAS #299-86-5

Toxicity Class: III **Use Class:** Not applicable

Chemical Name: 4-*tert*-Butyl-2-chlorophenyl methyl methylphosphoramidate

Common and Trade Names: Ruelene

Action: Insecticide, helminthicide

Properties: A white odorless crystalline powder, soluble in polar organic solvents and in water at 200 mg/L (Kenaga 1980).

Field Applications and Formulations: Crufomate is used as an insecticide and anthelmintic in cattle and sheep and is not used on crops. It is formulated as a drench, emulsifiable concentrate, and solution.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	>1,000		146
Rabbit	U	U	U	490		146
Rat	F	U	U	770		11
European starling	U	U	U	>100		225
Mallard	M	12	92	265	(170–414)	131
Red-winged blackbird	U	U	U	100	(56–178)	225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	2,000–4,000			146

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Production of crufomate has been discontinued by the manufacturer (Berg 1982). Crufomate is a broad-spectrum systemic anthelmintic used to control lice, grubs, and flies in cattle. It is administered orally, as a pour-on, or as a spray. It is not for use in lactating dairy cattle (Eto 1974). Acute oral toxicity test results vary widely among species; however, the data available suggest a relatively moderate to low acute toxicity. Crufomate has been reported to be nonaccumulative in fat tissues and relatively nonhazardous to wildlife (Worthing 1979). Reports of adverse effects on wildlife resulting from the use of crufomate have not been found in the current literature.

DDVP

CAS #62-73-7

Toxicity Class: II **Use Class:** Not applicable. Restricted

Chemical Name: 2,2-Dichlorovinyl dimethyl phosphate

Common and Trade Names: Atgard, Benfos, Canogard, Cekusan, Cypona, Dedevap, Devikol, Dichlorphos, Dichlorvos, Divipan, Duo-kill, Equigard, Fly-Die, Herkol, Krecalvin, Lindan, Mafu, Marvex, Nerkol, Nogos, No-Pest, Nuvan, Oko, Phosvit, Task, Vapona, Vaponite

Action: Insecticide

Properties: A colorless to amber liquid, miscible with most organic solvents and soluble in water at 10,000 mg/L.

Field Applications and Formulations: DDVP is an organophosphorus contact and stomach-poison insecticide with fumigant action. It is used to control household and public-health pests in the United States and has primarily nonagricultural uses. Outdoor fogging and applications to livestock and agricultural premises constitute most of its use. Formulations include aerosols, baits, emulsifiable concentrates, flea collars, resin strips, soluble concentrates, and sprays.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	M	A	V-2[a]	145		269
	F	A	V-2[a]	135		269
Rat	M	A	tech	80		80
	F	A	tech	56		80
European starling	U	U	U	12		225
Mallard	M	5-7	93	7.78	(6.0-10.1)	264
Red-winged blackbird	U	U	U	17		225
Ring-necked pheasant	M	3	93	11.3	(8.99-14.30)	264

[a]V-2 formulation specified in the original literature is assumed to be 20% Vapona.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	107			146
Rat	M	A	tech	107			80
	F	A	tech	75			80
	U	U	U			90-day feeding trials showed no intoxication at 1,000 ppm	285
Japanese quail	U	0.50	94.8		265	(191-370)	122
Mallard	U	0.50	94.8		>5,000	30% mortality at 5,000 ppm	124
	U	0.25	94.8		1,317	(1,043-1,674)	124
Ring-necked pheasant	U	0.30	94.8		568	(473-675)	124

Effects of Field Applications and Field Tests on Wildlife: Occurrences of nonaccidental applications of DDVP affecting wildlife have not been reported in the published literature. In one accident, eight adult mallards were suspected of dying from eating DDVP-treated horse feed (Ludke and Locke 1976). Generally, DDVP is not applied in the field where wildlife might be exposed.

Persistence and Hazard Evaluation: DDVP is a nonpersistent insecticide with extremely fast action in killing target organisms (Thomson 1982). The foliar surface half-life for DDVP is measured in hours, and it is rapidily lost through volatilization and hydrolysis (Food and Drug Administration 1982). Half-lives in soils are also extremely short (Food and Drug Administration 1982). Its relatively short residual activity and short half-lives under nonfield conditions (Eto 1974) indicate a low environmental persistence. DDVP also has a low predicted bioconcentration potential (Kenaga 1980).

DDVP is extremely toxic to birds and moderately toxic to mammals. It is also toxic to bees and fish (Thomson 1982). DDVP did not produce teratogenic effects through oral administration in mice given 60 mg/kg per day or rabbits given 5 mg/kg per day (Schwetz et al. 1979). Inhalation of DDVP, in these same species, also had no teratogenic effects at 4 μg/L for 7 h daily (Schwetz et al. 1979). DDVP is generally not applied under field conditions; therefore, wildlife exposure is expected to be minimal.

Demeton

CAS #8065-48-3

Toxicity Class: I

Use Class: V. Restricted

Chemical Name: *O,O*-Diethyl *O*-[2-(ethylthio)ethyl] phosphorothioate, mixture with *O,O*-diethyl *S*-[2-(ethylthio)ethyl] phosphorothioate

Common and Trade Names: Demox, Mercaptophos, Systemox, Systox

Action: Insecticide, acaricide

Properties: A light-brown liquid, soluble in water at 60 mg/L and in most organic solvents. Demeton is a mixture of two isomers, demeton-O (thiono isomer) and demeton-S (thiolo isomer) (Eto 1974).

Field Applications and Formulations: Demeton is an organophosphorus systemic insecticide and acaricide with contact, stomach-poison, and some fumigant activity. It is used to control several pests, especially sucking insects, such as aphids and mites. Demeton is applied to a variety of crops, with apples and grapes receiving the highest use. It is formulated in emulsifiable concentrates (25EC; 0.719 kg/L; 6 lb AI/gal).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic goat	M	U	92	8–18		264
Mule deer	F	A	92	<10.0		131
Rat	M	A	tech	6.2		80
	F	A	tech	2.5		80
California quail	F	6	92	10.6	(8.41–13.4)	131
Chukar	M/F	3	92	15.1	(12.0–19.0)	131
European starling	U	U	U	22		225
House finch	F	U	92	2.38	(2.00–2.83)[a]	131
House sparrow	F	U	92	9.52	(6.87–13.2)	264
Japanese quail	F	2	92	8.48	(6.73–10.7)	131
Mallard	F	3	99	7.19	(5.19–9.97)	131
Ring-necked pheasant	F	2	99	8.21	(5.69–11.9)	131
Rock dove	M/F	U	92	8.48	(6.73–10.7)	131
Sharp-tailed grouse	M/F	A	92	4.76	(4.00–5.66)[a]	264
Bullfrog	M	U	92	562	(178–1,780)	131

[a]Range of highest dosage producing no mortality to lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	24			146
Rat	M	A	tech	14			80
	F	A	tech	8.2			80
Japanese quail	U	0.5	96.0		275	(218–346)	122
Mallard	U	0.3	96.0		598	(488–733)	124
	F	10–11	92	24		(6.0–96.0)[a]	130
Northern bobwhite	U	I	96.0		596	(472–768)	124
Ring-necked pheasant	U	I	96.0		665	(572–773)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Demeton is a systemic insecticide and acaricide used to control sucking insects and mites on fruits, vegetables, and field crops. The technical product is a mixture of thiono (70%) and thiolo (30%) isomers, which are named Demeton-O and Demeton-S, respectively (Eto 1974). Demeton-O is more toxic and more soluble in water than Demeton-S (Eto 1974).

Demeton and two demeton-metabolite residues were found in lettuce following a field application of 1.0 kg AI/ha (0.88 lb/acre). Rapid disappearance of both demeton isomers and the rapid formation of the sulfoxide and sulfone metabolites of the thiolo isomer characterized residue behavior in lettuce. Both of the toxic sulfone and sulfoxide metabolites persisted up to 14 days (Coffin and McKinly 1964), and demeton has been reported to persist in soils up to 23 days (Pimental 1971). Demeton's long residual activity may be attributed to the systemic property of the chemical (Chemagro Corp. n.d.). The relatively low water solubility of demeton compared with other systemic insecticides has been explained by the conversion of the isomers to more water-soluble compounds within the plant (Hartley 1952).

Demeton is extremely toxic to birds and mammals through acute oral exposure. Dermal toxicity is also high for both birds and mammals, and acute dermal LD50's range from 8.2 to 24 mg/kg in the species tested. The dermal toxicity of demeton is greater than that of parathion and is attributed to its rapid absorption through the skin (Chemagro Corp. n.d.). Dietary LC50's for bird species fall in the moderate range (Hill et al. 1975) relative to other organophosphates. Data are not available to suggest wildlife die-offs or other problems with wildlife species related to the use of demeton. High acute toxicity to birds and mammals through both acute oral and dermal exposure indicates significant risk for wildlife exposed in treated areas. The rapid uptake by plants, and the specific types of crops receiving the major use of demeton, may reduce wildlife exposure to this chemical.

Demeton-methyl

CAS #8022-00-2

Toxicity Class: II **Use Class:** VI

Chemical Name: *O*-[2-(Ethylthio)ethyl] *O,O*-dimethyl phosphorothioate, mixture with *S*-[2-(ethylthio)ethyl] *O,O*-dimethyl phosphorothioate

Common and Trade Names: Metasystox, Methyldemeton

Action: Insecticide, acaricide

Properties: It is the methyl homolog of demeton and is a highly soluble liquid in organic solvents and water. Demeton-methyl is a mixture of thiolo and thiono isomers.

Field Applications and Formulations: Information not available.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat[a]	U	U	U	180		11
Rat[b]	U	U	U	64		11

[a]thiono isomer
[b]thiolo isomer

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: The production of demeton-methyl has been discontinued by the manufacturer (Berg 1982). Demeton-methyl belongs to a group of structurally related compounds and is the methyl homolog of demeton. Both insecticides are composed of thiono and thiolo isomers. Although demeton-methyl (Metasystox) is no longer produced, demeton (systox) and oxydemeton-methyl (Metasystox-R) are currently produced and used as insecticides. Results of one study indicated that demeton-methyl, and its related compounds, did not induce neurotoxic effects in hens or potentiate the toxicity of other anticholinesterase compounds (Vettorazzi 1976). Demeton-methyl is highly toxic to laboratory mammals; however, toxicity information for birds is lacking. Discontinuation of production and use likely results in little or no wildlife exposure.

Dialifor

CAS #10311-84-9

Toxicity Class: II **Use Class:** VI

Chemical Name: *O,O*-Diethyl hydrogen phosphorodithioate, *S*-ester with *N*-(2-chloro-1-mercaptoethyl)phthalimide

Common and Trade Names: Torak

Action: Insecticide, acaricide

Properties: A white crystalline solid, soluble in most aromatic hydrocarbons and in water at 0.18 mg/L (Kenaga 1980).

Field Applications and Formulations: Dialifor is an organophosphorus insecticide registered for use on pecans, citrus, grapes, and apples for the control of insects and mites (Berg 1982). It is formulated as an emulsifiable concentrate (0.479 kg/L; 4 lb/gal) and in wettable powder (50%; apples only; Berg 1982).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	39–65		146
Rabbit	U	U	U	35–71		146
Rat	M	U	tech	43–53		11
	M	U	4EC	62		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	145			146

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Dialifor is a nonsystemic foliar insecticide and acaricide used on a limited number of crops to control insects and mites. Dissipation of dialifor applied to grapes was slower than for many organophosphates (Winterlin et al. 1980), and applications to oranges and lemons indicated half-lives from about 40 to 80 days (Westlake et al. 1971). The half-life of dialifor in soil varies from about 25 to 30 days (Thomson 1982). Of the currently registered organophosphates, dialifor has the largest predicted bioconcentration factor (BCF = 1,625 predicted from water solubility; Kenaga 1980).

Dialifor is a highly toxic organophosphate, and LD50's for mammals vary widely according to species and sex (Eto 1974). Avian toxicity data are not available; however, dialifor is toxic to fish and bees (Thomson 1982). Adverse effects on wildlife resulting from the use of dialifor have not been reported, and the limited number of acres treated likely minimize wildlife exposure. Information on the avian toxicity and environmental fate of dialifor are needed.

Diamidfos

CAS #1754-58-1

Toxicity Class: II **Use Class:** VI

Chemical Name: Phenyl *N,N'*-dimethylphosphorodiamidate

Common and Trade Names: Nellite

Action: Nematicide

Properties: A white crystalline solid, soluble in water at 40,000 mg/L.

Field Applications and Formulations: Diamidfos is an organophosphorus systemic nematicide used on tobacco to control root-knot nematodes.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	U	140		11
European starling	U	U	U	75		225
Red-winged blackbird	U	U	U	13	(5.6–32)	225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	100–200			11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Diamidfos production has been discontinued by the manufacturer (Berg 1982). It is used to control soilborne nematodes on tobacco, and data on its environmental fate and persistence are not available. Diamidfos does not accumulate in aquatic food-chain organisms (Berg 1982), and its predicted bioconcentration factor is low. Diamidfos was extremely toxic to red-winged blackbirds (Schafer 1972), and its apparent toxicity to rats is high. There have been no reports of diamidfos applications resulting in wildlife die-offs. Discontinuation of diamidfos production and subsequent low or no volume field use indicates a current low potential for exposure to wildlife.

Diazinon

CAS #333-41-5

Toxicity Class: III **Use Class:** IV

Chemical Name: *O,O*-Diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate

Common and Trade Names: Basudin, Dazzel, Diagran, Dianon, DiaterrFos, Diazajet, Diazide, Diazital, Diazol, Dizinon, Dyzol, Gardentox, Kayazinon, Kayazol, Knox-Out, Neocidol, Nipsan, Nucidol, Sarolex, Spectracide

Action: Insecticide, acaricide

Properties: A colorless liquid, soluble in water at 40 mg/L and miscible in most organic solvents. It is stable under alkaline conditions but is hydrolyzed by water and dilute acids.

Field Applications and Formulations: Diazinon is an organophosphorus insecticide and acaricide with stomach-poison and contact activity. It has a broad spectrum of activity and is applied to a variety of crops, grasslands, turf, buildings, livestock, and is also used as a seed treatment. A cancellation notice for diazinon use on golf courses and sod farms has been issued (Federal Register 1986); however, hearings on certain products have been requested. Major-use agricultural crops include almonds, corn, apples, and tobacco. It is applied to corn, cotton, and soybeans as a seed treatment. Diazinon is available in aerosol (0.5%), dusts (2 and 50%), emulsifiable concentrates (4EC; 60%), granules (2, 10, and 14G), liquid concentrate (25%), and wettable powders (40 and 50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	U	U	tech	240–320		84
Mouse	U	U	tech	80–135		84
	U	U	25% WP	89–123		84
Rabbit	U	U	tech	130		84
Rat	M	A	tech	250	(231–270)	80
	F	A	tech	285	(259–314)	80
European starling	U	U	U	110	(60–200)	225
Mallard	M	3–4	89	3.54	(2.37–5.27)	131
Northern bobwhite	M/F	A	tech	10	(7–13)	121
	M/F	A	14G	8	(6–11)	121
Red-winged blackbird	U	U	U	2.0		225
Ring-necked pheasant	M	3–4	89	4.33	(3.02–6.22)	131
Bullfrog	F	U	89	>2,000		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	WP			271 daily doses of 4.3–5.3 mg/kg per day resulted in no gross signs of toxicity but significant RBC and plasma ChE inhibition	43
Rabbit	U	U	tech	3,600			11
	U	U	4E	600			11
Rat	M	A	tech	200–900			80
	F	A	tech	455			80
	U	U	WP			2-year chronic study at 10, 100, and 1,000 ppm resulted in no significant differences in mortality, food consumption, or signs of toxicity compared to controls	43
Japanese quail	U	0.5	99		167	(131–212)	122
	U	0.5	48		101	(81–126)	122
Mallard	U	0.3	92.1		191	(138–253)	124
						External applications to eggs at concentrations similar to field applications resulted in teratogenic effects	127
Northern bobwhite	U	0.3	92.1		245	(178–324)	124
	M/F	A	0.479 kg/L (4 lb/gal)			Food consumption and egg production negatively related to dose above 35 ppm	257
Ring-necked pheasant	U	0.6	92.1		244	(177–322)	124
	M/F	A	96.6			Normal daily food intake containing as low as 6–12% of diazinon-treated seed corn could affect food consumption and egg production (threshold of 1.05–2.10 mg/day)	256

Effects of Field Applications and Field Tests on Wildlife: Numerous reports of Canada goose mortality following the application of diazinon to golf courses are described in the literature (Zinkl et al. 1978; Stone 1979; Hazard Evaluation–EPA 1981; Coon 1983, personal communication). These occurrences are generally reported without information on application rates and procedures. One incident involving the death of about 140 Canada geese, gadwalls, and American wigeons was reported for an area on or adjacent to a field that had been sprayed with diazinon. All specimens had brain ChE activity inhibited at least 55% compared to controls, and diazinon residues were found in gastrointestinal tracts in 4 of 5 specimens (Hill and Fleming 1982). Avian mortality resulting from applications of diazinon to rangelands, at rates of 426–703 g/ha (6.0–9.9 fl oz/acre), have also been reported in the literature (McEwen 1982).

Persistence and Hazard Evaluation: Diazinon is an insecticide and acaricide with stomach poison and contact activity. It has a wide range of pest-control applications and has long residual effects (Thomson 1982).

Diazinon applied to tobacco at 0.84 kg/ha (0.75 lb/acre) resulted in undetectable residues (<0.1 mg/kg) in tobacco hornworms 18 days after spraying. Nondetectable (<0.5 mg/kg) residues in hornworms of diazoxon, a toxic metabolite, were reported and the potential hazard to birds eating those insects was concluded to be minimal (Stromborg et al. 1982). In the environment, diazinon is moderately persistent and half-lives in soil are about 4–6 weeks (Von Rumker et al. 1974). Half-lives on and in citrus fruits ranged from 13 to 17 days (Gunther 1969). Experimental work on the bioconcentration potential of this insecticide is lacking; however, its predicted bioconcentration is moderately low.

Diazinon is extremely toxic to birds and moderately toxic to mammals. It is reported to be toxic to fish, lower aquatic organisms, and bees (Von Rumker et al. 1974; Thomson 1982). Acute oral LD50's for wild bird species are low and avian die-offs have resulted from the use of diazinon. There have been reports of waterfowl, particularly geese, dying as a result of diazinon applications to golf courses, although few data concerning application rates and procedures are available. The large number of wildlife die-offs associated with use of diazinon on golf courses has resulted in a cancellation notice being issued for use on golf courses and sod farms (Federal Register 1986). Applications of this insecticide should be made only after careful evaluation of potential wildlife exposure.

Dicapthon

CAS #2463-84-5

Toxicity Class: III **Use Class:** Not applicable

Chemical Name: *O*-(2-Chloro-4-nitrophenyl) *O*,*O*-dimethyl phosphorothioate

Action: Insecticide

Common and Trade Names: Di-Captan

Properties: A crystalline powder, soluble in aromatic hydrocarbons and in water at 35 mg/L.

Field Applications and Formulations: Dicapthon is an organophosphorus insecticide not applied to crops but is used for the control of household insects.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	A	tech	400		80
	F	A	tech	330		80

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	A	tech	790			80

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	F	A	tech	1,250			80
	U	U	U			1-year feeding trial with no effect on growth at 25 mg/kg diet	63

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Dicapthon production has been discontinued by the manufacturer (Berg 1982). It is an insecticide used for the control of cockroaches as well as structural and household pests and is not used in crop protection (Berg 1982). Information on its environmental persistence and fate are not available. Dicapthon is of moderately acute oral toxicity to rats, the only species for which toxicity information is available. Discontinuation of dicapthon production and its apparent disuse in the field indicate a low current potential exposure to wildlife.

Dichlofenthion

CAS #97-17-6

Toxicity Class: III

Use Class: Not applicable

Chemical Name: *O*-(2,4-Dichlorophenyl) *O,O*-diethyl phosphorothioate

Action: Nematicide, insecticide

Common and Trade Names: Dichlorofenthion, Mobilawn

Properties: A colorless liquid, miscible with organic solvents and soluble in water at 0.24 mg/L.

Field Applications and Formulations: Dichlofenthion is a nonsystemic organophosphorus nematicide and insecticide used on turf, shrubs, and ornamentals to control nematodes and chinch bugs. It is not used for crop protection and is formulated as an emulsifiable concentrate (75%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	270		11
European starling	U	U	U	80	(25–250)	225
Red-winged blackbird	U	U	U	14		225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			90-day feeding trial with no toxicological effects at 0.75 mg/kg per day	63

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	6,000			285

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Dichlofenthion production has been discontinued by the manufacturer (Berg 1982). It is applied to turf and other nonagricultural sites for the control of nematodes and soilborne insects (Berg 1982). It has long residual activity and may persist in soils for 1–2 years following application (Eto 1974). Acute oral and dermal toxicities of dichlofenthion are moderate to low for rats and rabbits, respectively. However, it is extremely toxic to red-winged blackbirds (Schafer 1972). Due to lack of production and an estimated low, or no, field use, exposure to wildlife is probably minimal.

Dicrotophos

CAS #141-66-2

Toxicity Class: I **Use Class:** III. Restricted

Chemical Name: Dimethyl hydrogen phosphate ester with (*E*)-3-hydroxy-*N*,*N*-dimethyl crotonamide

Common and Trade Names: Bidrin, Carbicron, Ektafos

Action: Insecticide, acaricide

Properties: An amber liquid, miscible in water and in organic solvents.

Field Applications and Formulations: Dicrotophos is an organophosphorus systemic and contact insecticide and acaricide with a broad spectrum of activity. It is used primarily on cotton, with soybeans and sorghum receiving some applications as well. It has been used to control elm bark beetles and is applied to a variety of crops including rice, coffee, and citrus outside of the United States (Thomson 1982).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	11–16		11
Mule deer	M	8–17	98[a]	12.5–25.0		131
Rat	M	A	tech	21	(18–25)	80
	F	A	tech	16	(14–18)	80
California quail	M	18	80	1.89	(1.50–2.38)	131
Canada goose	M/F	U	98	2.28	(1.36–3.83)	131
Chukar	M/F	12–24	98	9.63	(7.35–12.9)	131
European starling	U	U	U	2.7	(0.85–8.5)	225
	U	0.5 days	U	4.92	(3.98–6.48)	102
	U	0.5 days	U	9.59	(7.60–12.07)	102
	M	⩾12	U	8.37	(6.30–10.51)	102
	F	⩾12	U	8.47	(5.45–11.42)	102
House finch	M/F	U	98	2.83	(1.06–7.54)	131
House sparrow	M	U	98	3.00	(1.59–5.64)	131

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Japanese quail	M	2.5	98	4.32	(3.18–5.86)	131
Mallard	M	3	98	4.24	(3.06–5.88)	131
Red-winged blackbird	U	U	U	1.6	(0.5–5.0)	225
Ring-necked pheasant	M	2	98	3.21	(2.45–4.21)	131
Rock dove	M/F	U	98	2.00	(1.53–2.61)	131
Sharp-tailed grouse	M	24–36	98	2.31	(1.78–3.00)	131
Bullfrog	M	U	98	2,000	(602–6,640)	131

[a]α-isomer.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			"No effect" chronic dietary level of 1.6 ppm in the diet after 2 years	285
Rabbit	U	U	U	112–400			285
Rat	M	A	tech	43			80
	F	A	tech	42			80
	U	U	U			No observable effect level of 2 mg/kg daily in a 3-generation reproduction study	285
Rat	U	U	U			"No effect" chronic dietary level of 1 ppm in the diet after 2 years	285
Common grackle	M/F	A	85		17–125		98
Japanese quail	U	0.50	85		37	(34–40)	122
Mallard	M	A	80	14.2		(4.56–43.8)[a]	130
	U	0.30	85		144	(110–185)	124
	U	0.15	85		94	(80–111)	124
Ring-necked pheasant	U	0.30	85		44	(38–51)	124

[a]95% CL for acute dermal (24 h) LD50.

Effects of Field Applications and Field Tests on Wildlife: Free-living female European starlings given a single oral dose of dicrotophos (2.5 mg/kg of body weight) in corn oil made significantly fewer visits to feed their young and remained away from their young for longer periods of time than did starlings dosed with pure corn oil. Brain cholinesterase activity was reduced 50% in dosed females; parental care may be significantly reduced in songbirds by a severe, but sublethal, exposure to dicrotophos (Grue et al. 1982). Male starlings orally dosed with dicrotophos (2.5 mg/kg of body weight) spent more time perching and less time flying, singing, and displaying compared with controls. Male starling activity returned to normal within 26–28 h after treatment (Grue and Shipley 1981).

A die-off of approximately 30 great-tailed grackles was attributed to either intentional poisoning or gross misuse of dicrotophos (Mitchell et al. 1984).

Dicrotophos applied on rangelands to control grasshoppers at 142 g/ha (2.0 fl oz/acre) resulted in bird mortality and notable reductions in bird numbers (McEwen 1982).

Persistence and Hazard Evaluation: Dicrotophos is a fast-acting systemic and contact insecticide with relatively low environmental persistence. Applied as a foliar spray at 0.6 and 1.1 kg AI/ha (0.5 and 1.0 lb/acre), dicrotophos residues on green alfalfa declined from 43 to 0.19 mg/kg and from 64 to 0.42 mg/kg in 21 days, respectively (Shaw et al. 1966). Dried alfalfa residues declined to 0.21 and 1.1 mg/kg after 23 days for the same low and high application rates, respectively (Shaw et al. 1966). Major degradation products of toxicological importance include N-methyl-N-hydroxyl methyl dicrotophos and monocrotophos, another organophosphate insecticide (Food and Drug Administration 1982). Half-lives on foliage range from about 1 to 4 days and, under moist aerobic conditions in soils, are less than 6 days (Food and Drug Administration 1982). Dicrotophos is water soluble and is readily leached through soil (Corey 1965). It was not greatly bioconcentrated in tadpoles exposed at 5 mg/L; however, ducklings fed contaminated tadpoles did have an average brain cholinesterase activity inhibition of 70% (Hall and Kolbe 1980).

Dicrotophos is extremely toxic to birds and mammals, and both the parent compound and its metabolite, monocrotophos, are potent cholinesterase inhibitors. European starling nestlings orally dosed with dicrotophos were nearly twice as sensitive as adults although brain ChE recovered more rapidly in nestlings (Grue and Shipley 1984). At a dosage of 2.5 mg/kg of body weight, dicrotophos has been shown to modify the behavior of free-living starlings (Grue and Shipley 1981; Grue et al. 1982). Differences in the response of brain ChE activity to dicrotophos exposure in five different wild bird species were up to eightfold, indicating a marked species variability (Fleming and Grue 1981). There are relatively few data available on wildlife problems related to the use of this highly toxic and widely used insecticide. Careful evaluation of potential wildlife exposure should be made prior to application, especially with respect to the timing of bird reproduction and possible sublethal adverse effects.

Dimethoate

CAS #60-51-5

Toxicity Class: I **Use Class:** III

Chemical Name: *O*,*O*-Dimethyl hydrogen phosphorodithioate, *S*-ester with 2-mercapto-*N*-methylacetamide

Common and Trade Names: Cekuthoate, Cygon, Daphene, De-Fend, Demos L40, Devigon, Dimate 267, Dimethogen, Fosfamid, Fostion MM, Perfekthion, Rebelate, Rogodial, Rogor, Roxion, Trimetion

Action: Insecticide, acaricide

Properties: The technical product is a white crystalline solid, soluble in most organic solvents, and soluble in water at 25,000 mg/kg. It is not compatible with alkaline pesticides.

Field Applications and Formualtions: Dimethoate is an organophosphorus systemic insecticide and acaricide applied to a variety of field crops, fruits, nut trees, and vegetables to control a broad range of insects and mites. Major-use crops include cotton, edible beans, peas, alfalfa, and pecans. It is available in dusts (4, 5, and 10%), emulsifiable concentrates (2 and 2.67EC), granules (10%), and wettable powders (25 and 50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	400		146
Mouse	U	U	U	200–250		146
Mule deer	M/F	U	97	>200		285

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rabbit	U	U	U	300–500		146
Rat	M	A	tech	215	(189–245)	80
	F	A	tech	30	(27–33)	80
	F	A	tech	245	(209–287)	80
	M	U	U	215		11
	M	A	tech	28	(25–31)	80
Blackbird, unspecified	U	U	U	26		285
Duck, unspecified	F	U	U	40		285
European starling	U	U	U	32	(25–41)	225
House sparrow	U	U	U	22		285
Mallard	M	3–4	97	41.7	(30.1–57.8)	131
	M	3–4	99.8	63.5	(45.8–88.1)	131
Red-winged blackbird	U	U	U	6.6	(3.6–12)	225
Ring-necked pheasant	F	3–4	97	20.0	(15.9–25.2)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Mouse			tech			60 mg/L in drinking water over five generations reduced reproductive performance and growth of young	22
Rat	M	A	tech	61			80
	M	A	tech	610			80
	F	A	tech	55			80
	F	A	tech	610			80
	U	U	U			Chronic dietary 5 mg/kg with "no effect" at 90 days	146
Japanese quail	U	0.5	99		341	(286–407)	122
	U	0.5	23.4		496	(373–659)	122
Mallard	U	0.3	99		1,011	(707–1,372)	124
Ring-necked pheasant	U	0.3	99		332	(293–376)	124

Effects of Field Applications and Field Tests on Wildlife: Dimethoate spray was applied to a 20.8-ha (52-acre) test plot at 0.6 kg/ha (0.5 lb/acre) without visible effects on wildlife (Pillmore and Peterson 1963). Domestic rabbits, held in enclosures during the application, did not have reduced blood plasma cholinesterase activity. Another series of enclosures were treated with 2.3 and 3.4 kg dimethoate/ha (2.0 and 3.0 lb/acre) and post-spray blood samples from rabbits did have reduced cholinesterase activity (Pillmore and Peterson 1963).

Persistence and Hazard Evaluation: Dimethoate is a systemic insecticide and acaricide that also has contact and residual activity. It is rapidily absorbed, and its half-life is estimated to be about 19 days when applied to oranges (Gunther 1969). Applied to soil at 1.1 kg actual/ha (1 lb/acre) as an emulsifiable concentrate, one-half of the insecticide disappeared in 2–4 days (Bohn 1964). Foliar applications to plants at rates equivalent to 0.6 g/L (0.5 lb/100 gal) water, resulted in only trace amounts of the parent compound and its oxygen analog after 32 days (Dauterman et al. 1960). High water solubility and low predicted bioconcentration, as well as field experiments, suggest that dimethoate has a relatively short environmental persistence.

Dimethoate is of moderate acute oral toxicity to laboratory mammals; however, acute toxicological data indicate that it is extremely toxic to birds (Schafer 1972). Although this pesticide is widely used and highly toxic to certain wildlife species, there have been no published reports indicating dimethoate as the causative agent in any wildlife die-offs. Low environmental persistence, as well as the types of crops that it is applied to, may reduce its exposure to wildlife species.

Dioxathion

CAS #78-34-2

Toxicity Class: I **Use Class:** VI. Restricted

Chemical Name: *S,S'*-*p*-Dioxane-2,3-diyl bis[*O,O*-diethyl phosphorodithioate]

Common and Trade Names: Delnav, Deltic

Action: Insecticide, acaricide

Properties: The technical product is a brown liquid, soluble in most organic solvents and insoluble in water. Although very stable, it is hydrolyzed by alkali or heat.

Field Applications and Formulations: Dioxathion is a contact and stomach-poison organophosphorus insecticide and acaricide used to control insects and mites on crops and livestock. The major-use field crop is cotton, with some use on grapes, citrus, apples, and pears. It is formulated as emulsifiable concentrates (4 and 8EC) and as a livestock dip (15 and 30%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	10–40		146
Mouse	U	U	U	50–176		146
Rat	M	U	U	43		285
	F	U	U	23		285
Mallard	M	3–4	72	277	(172–443)	131
Ring-necked pheasant	M	3–7	72	240	(190–302)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	107			146
Rat	M	U	U	235			285
	F	U	U	63			285
Japanese quail	U	0.5	100		6,130	(4,766–7,806)	122
Mallard	U	0.5	tech		3,600		124
Ring-necked pheasant	U	0.3	tech		4,067	(3,593–4,610)	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Dioxathion is a narrow-spectrum insecticide and acaricide with long residual effectiveness. The technical product is a mixture of cis and trans isomers, and the oxygen analog of dioxathion is relatively unstable (Vettorazzi 1976). Half-lives for residues in and on citrus are from 70 days to more than 100 days (Gunther 1969). Dioxathion is not readily hydrolyzed on plant surfaces (Vettorazzi 1976), and it is a moderately persistent organophosphate. The insolubility of dioxathion in water suggests a high predicted bioconcentration factor; however, experimental data on its bioconcentration are not available.

Dioxathion has moderate to extreme acute toxicity in mammal species tested and is moderately toxic to birds. Dietary LC50's for birds indicate relatively low toxicity through this type of exposure. Because of low total field use, and the specific crops receiving dioxathion applications, it is likely that wildlife exposure is minimal. There are no published reports of dioxathion causing wildlife die-offs.

Disulfoton

CAS #298-04-4

Toxicity Class: I — **Use Class:** III. Restricted

Chemical Name: *O,O*-Diethyl *S*-[2-(ethylthio)ethyl] phosphorodithioate

Common and Trade Names: Dimaz, Di-Syston, Disyston, Dithiodemeton, Dithiosystox, Frumin AL, Solvirex, Thiodemeton

Action: Insecticide, acaricide

Properties: Disulfoton is a yellow liquid, soluble in water at 225 mg/L and readily soluble in most organic solvents. It is stable under normal conditions and subject to hydrolysis at pH's greater than 8.0.

Field Applications and Formulations: Disulfoton is an organophosphorus systemic insecticide applied in the seed furrow, as a side dressing, broadcast, or as a foliar spray to control insects and mites. Cotton receives most of the seed-treatment applications, and for other types of applications, major crops include wheat, sorghum, cotton, soybeans, and potatoes. Disulfoton is formulated as an emulsifiable concentrate (6EC), granules (5–15%), seed dressing powder, and wettable powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic goat	M	>60	97	<15.0		131
Mule deer	F	10	97	2.5–5.0		131
Rat	M	A	tech	6.8	(5.9–7.8)	80
	F	A	tech	2.3	(1.7–3.1)	80
	U	U	tech	2–12		11
European starling	U	U	U	>32		225
Mallard	M	3	97	6.54	(3.76–11.4)	131
Northern bobwhite	M/F	A	tech	12	(7–19)	121
	M/F	A	15G	29	(24–34)	121
Red-winged blackbird	U	U	U	3.2	(1.8–5.6)	225
Ring-necked pheasant	M	3	97	11.9	(8.58–16.5)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			"No effect" dietary level of 1 ppm in the diet	34
Rat	M	A	tech	15			80
	F	A	tech	6			80
	U	U	U			"No effect" dietary level of 2 ppm in the diet	34
Japanese quail	U	0.5	tech		333	(282–392)	124
	U	0.5	100		334	(275–405)	122
Mallard	U	0.3	tech		510	(415–625)	124
	M	A	97	192		(96.0–384)[a]	130
Northern bobwhite	U	0.5	tech		715	(617–827)	124
Ring-necked pheasant	U	0.3	tech		634	(547–737)	125

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: An unconfirmed incident recorded by the EPA Pesticide Incident Monitoring System (Hazard Evaluation–EPA 1981) reported 50 animals killed including cottontail rabbits, jack rabbits, American crows, and pheasants in an area where disulfoton was applied by air. State authorities reportedly received calls about wildlife mortality from an 8–10 county area (Hazard Evaluation–EPA 1981).

Persistence and Hazard Evaluation: Disulfoton is a systemic insecticide and acaricide with a moderately broad spectrum of activity. It is of moderate environmental persistence, and its predicted bioconcentration potential is low. In the environment, disulfoton is converted to sulfoxide and sulfone metabolites that also have insecticidal activity (Takase et al. 1972). Residual insecticidal activity may last up to 6–8 weeks after treatment (Chemagro Corporation 1971*b*). Oxidation analogs, which also have sulfoxide and sulfone metabolites, are produced faster under flooded conditions but are less stable (Takase et al. 1972).

Disulfoton is extremely toxic to birds and mammals as well as fish, aquatic organisms, and bees (Thomson 1982). Laboratory toxicity studies have determined very low acute oral LD50's for both birds and mammals. Disulfoton is rapidly absorbed through the skin and acute dermal LD50's are also low. Thionate oxidation of disulfoton produces demeton, another organophosphate of high acute toxicity (Vettorazzi 1976). Evaluation of potential field applications should also consider the presence of demeton and its oxygen analog, demeton-S. Despite its high toxicity and wide use, there have been few reports of wildlife die-offs that can be attributed to disulfoton applications.

High acute oral and dermal toxicity, long residual and systemic activity, and moderate persistence indicate that a careful evaluation of potential wildlife exposure should be made prior to application.

EPN

CAS #2104-64-5

Toxicity Class: I

Use Class: III. Restricted

Chemical Name: *O*-Ethyl *O*-(*p*-nitrophenyl) phenylphosphonothioate

Common and Trade Names: EPN

Action: Insecticide, acaricide

Properties: A light-yellow crystalline powder with low water solubility. EPN is stable under slightly acidic conditions and is hydrolyzed under alkaline conditions.

Field Applications and Formulations: EPN is a nonsystemic organophosphorus insecticide and acaricide used to control a variety of insects and mites. It is applied at rates of 0.2 to 13.6 kg actual/ha (0.125 to 12 lb/acre; Thomson 1982). The principal crop is cotton, and it has also been used as a mosquito larvicide. EPN is formulated in dust (1.5%), emulsifiable concentrates (2EC; 4EC), granules (15%), and wettable powders. It is sometimes used in combination with methyl parathion.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	100–200		146
Mouse	U	U	U	43		11
Rat	U	U	U	26		11
California quail	F	5–6	91	36.3	(28.0–47.1)	131
Chukar	F	3	91	14.3	(10.3–19.8)	131
European starling	U	U	U	7.5		225
House sparrow	F	U	91	12.6	(7.16–22.2)	131
Japanese quail	F	2	91	5.25	(3.79–7.28)	131
Mallard	M	4–5	87.7	7.09	(5.18–9.69)	130
	F	3	91	3.08	(2.38–4.00)	131
Red-winged blackbird	U	U	U	3.2	(1.8–5.6)	225
Ring-necked pheasant	F	3–5	91	53.4	(38.5–74.1)	131
Rock dove	M/F	U	91	5.90	(4.25–8.17)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			Chronic oral "no effect" level of 80 ppm at 90 days	146
Mouse	U	A	30			Single sublethal dose (20 mg/kg) resulted in irreversible ataxia	62
Rat	U	U	U			Chronic oral "no effect" level of 5–25 ppm at 90 days	146
Japanese quail	U	0.5	100		437	(302–632)	122
Mallard	U	0.5	tech		168	(125–237)	124
	U	0.3	tech		330		124
Northern bobwhite	U	0.3	tech		349	(289–411)	124
Ring-necked pheasant	U	0.5	tech		1,075	(943–1,230)	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistance and Hazard Evaluation: EPN is an insecticide and acaricide with relatively long residual effectiveness (Thomson 1982). It is only slightly soluble in water, suggesting that its predicted bioconcentration factor is likely high compared with other organophosphates. It has been demonstrated to be markedly more bioaccumulative and persistent than parathion under certain conditions (Francis et al. 1980) and has been found to bioconcentrate in some estuarine animals (Schimmel et al. 1979). Residue half-lives for lemons and oranges were determined to be 80 and 50 days, respectively (Gunther 1969).

Laboratory studies have shown that EPN is extremely toxic to birds and mammals through acute oral exposure. Although it is rapidly absorbed through skin (Berg 1982; Thomson 1982), its percutaneous toxicity to mallards was much lower than its acute oral toxicity (Hudson et al. 1979). EPN is also toxic to bees and fish (Thomson 1982).

A review of pesticide interactions in vertebrates cited several studies of the potentiation of malathion toxicity by EPN (Murphy 1969). In certain species, EPN inhibits enzymes that detoxify malathion, and EPN has also caused potentiation of dimethoate toxicity in some species (Murphy 1969). Delayed neurotoxic effects of EPN have been demonstrated in hens (Abou-Donia and Graham 1979) and in mice (El-Sebae et al. 1977). White mice given a single sublethal oral dose of EPN at 20 mg/kg became irreversibly ataxic after 29 days (El-Sebae et al. 1977).

Although EPN has not been reported as the causative agent in die-offs of wild birds and mammals, it is a relatively toxic and persistent organophosphate. It has been shown to cause delayed neurotoxicity in certain bird and mammal species and has also been found to potentiate the toxicity of less toxic pesticides such as malathion. Its high acute toxicity, possible bioconcentration, sublethal effects, and interactions with other pesticides should be considered with respect to potential wildlife exposure.

Ethion

CAS #563-12-2

Toxicity Class: I **Use Class:** IV

Chemical Name: *S,S'*-Methylene bis[*O,O*-diethyl phosphorodithioate]

Common and Trade Names: Diethion, Embathion, Ethanox, Ethiol, Ethodan, Hylemox, Itopaz, Kwit, Nialate, Rhodiacide, Rhodocide, Vegfru Fosmite

Action: Insecticide, acaricide

Properties: A colorless to amber liquid, nearly insoluble in water at 2 mg/L and soluble in most organic solvents. It is hydrolyzed under acidic and alkaline conditions and is slowly oxidized in air (Worthing 1979).

Field Applications and Formulations: Ethion is an organophosphorus nonsystemic insecticide and acaricide applied to a variety of crops to control aphids, mites, scales, and other pests. Major use is on oranges, with grapefruit and apples also treated with substantial quantities. Ethion is formulated in dusts (2, 3, and 4%), emulsifiable concentrates (4EC; 8EC), granules (5, 8 and 10%), solution (50%), wettable powder (25%), and in various oil solutions. Ethion is also combined with other pesticides.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	A	tech	65	(55–77)	80
	F	A	tech	27	(23–31)	80
	U	U	pure	208		11
European starling	U	U	U	>304		225
Mallard	F	3	95	>2,560		131
Red-winged blackbird	U	U	U	45		225
Ring-necked pheasant	F	3–4	95	1,297	(745–2,257)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	915			285
Rat	M	A	tech	245		(208–289)[a]	80
	F	A	tech	62		(56–69)[a]	80
	F	U	U			28-day feeding trial at 300 ppm in the diet had no effect on growth, but ChE inhibition occurred at levels >10 ppm	285
Japanese quail	U	0.5	95.0		>5,000	No mortality to 1,000 ppm	122, 124
Mallard	U	0.3	95.0		>5,000	No mortality to 1,000 ppm	124
Ring-necked pheasant	U	0.3	95.0		>5,000	25% mortality at 2,000 ppm	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Penned turkeys were exposed to soil sprayed with ethion (0.479 kg/L; 4 lb/gal EC) at rates of 4.5, 13.6, and 45.2 kg AI/ha (4, 12, and 40 lb/acre). Highest residues were found in turkey fat and skin. Residues at 1 week following treatment ranged from 0.022 mg/kg in turkey fat at the 4.5 kg/ha (4 lb/acre) treatment to 0.666 mg/kg in skin at 45.2 kg/ha (40 lb/acre). No reference to sickness or mortality of these birds was made (Ivey et al. 1975).

Persistence and Hazard Evaluation: Ethion is a nonsystemic insecticide and acaricide with relatively long residual activity (Thomson 1982). Degradation of ethion is through photodecomposition and oxidation. The two primary oxygen analogs are ethion monooxon and dioxon (Leffingwell et al. 1975). These analogs are formed when foliar applications of wettable powder formulations are made but not when an emulsifier is added (Vettorazzi 1976). The potential toxicity and ChE-inhibitory effects of these analogs have not been evaluated. Half-lives in and on citrus fruits have been reported to be about 30–42 days (Gunther 1969). Little information is available on environmental persistence following actual field applications; however, because of ethion's low water solubility (2 mg/L), its predicted bioconcentration factor (flowing-water systems) is moderately high (>400) (Kenaga 1980).

Ethion has high to moderate acute oral toxicity in laboratory and wildlife species, while dietary LC50 tests show this insecticide to be of relatively low subacute dietary toxicity in bird species (Hill et al. 1975). Ethion is reported to be toxic to fish, bees, and wildlife (Thomson 1982), and tests results for teratogenicity in rats and neurotoxicity in hens were negative (Vettorazzi 1976). Wildlife die-offs, or other wildlife problems, associated with the use of ethion have not been found in the literature.

Toxicological test results for ethion indicate a possible wide range of toxicity, perhaps due to exposure type, formulation, and species differences. More information on environmental fate and wildlife toxicity is needed. Application to certain crops, such as citrus, may minimize wildlife exposure to ethion, although some minor-use crops may provide wildlife habitat.

Ethoprop

CAS #13194-48-4

Toxicity Class: II **Use Class:** III. Restricted

Chemical Name: *O*-Ethyl *S*,*S*-dipropyl phosphorodithioate

Common and Trade Names: Ethoprophos, Mocap, Prophos, Rovokil, VC 9-104

Action: Nematicide, soil insecticide

Properties: Soluble in water at 750 mg/L.

Field Applications and Formulations: Ethoprop is an organophosphorus contact nematicide and soil insecticide, without fumigant activity (Berg 1982; Thomson 1982), applied to field crops and turf. The major crop is corn, and other important crops include tobacco, peanuts, soybeans, and sugarcane. Ethoprop is available as an emulsifiable concentrate (6EC) and in granules (10 and 15G).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	61.5		11
Mallard	F	3	95.8	12.6	(10.6–15.0)[a]	131
Ring-necked pheasant	M	3–4	95.8	4.21	(3.03–5.83)	131

[a]Range of highest dose producing no mortality to the lowest dose producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	26			146
Japanese	U	0.50	95.8		89	(72–109)	122
quail	U	0.50	6E		91	(68–122)	122
	U	0.50	10G		90	(78–122)	122
Mallard	U	0.30	95.8		550		124
	U	0.15	95.8		287	(215–382)	124
	M	A	95.8	10.6		(7.5–15.0)[a]	130
Northern bobwhite	U	0.50	95.8		33	(27–40)	124
Ring-necked pheasant	U	0.30	95.8		118	(103–134)	124

[a]Range of the highest dose producing no mortality to the lowest dose producing 100% mortality.

Effects of Field Applications and Field Tests on Wildlife: American robins were found on a lawn at a residence that had been treated approximately 30 days earlier with ethoprop. Six birds died and one examined had brain ChE inhibited 74% and ethoprop in its gastrointestinal tract (Coon 1983, personal communication).

Persistence and Hazard Evaluation: Ethoprop is a soil nematicide and insecticide with moderately long residual activity (8 weeks; Thomson 1982). Few data are available describing its persistence and fate in the environment. The half-life of ethoprop in humic and peaty sand was reported as 87 days and ranged between 14 and 28 days in a sandy loam soil (Menzie 1980). It is slightly soluble in water and its predicted bioconcentration factor is very low. Information concerning its persistence under flooded conditions is not available.

The limited amount of acute toxicity data available for ethoprop indicates high acute oral and dermal toxicity to birds and mammals. It is rapidly absorbed through skin, and acute dermal LD50's are low. Dietary LC50 values for young birds indicate a high to moderately high subacute toxicity compared with other organophosphates.

Despite the high toxicity and moderately high amount of acre treatments of ethoprop applied in the field, there is little information relating its use to wildlife mortality. Like other highly toxic and widely used soil insecticides, it appears that wildlife exposure to this chemical has either been minimal or has gone largely unreported. Because of its high toxicity, applications of ethoprop should be carefully made to ensure all of the material is fully incorporated into the soil to avoid exposure to wildlife.

Famphur

CAS #52-85-7

Toxicity Class: I

Use Class: Not applicable

Chemical Name: *O,O*-Dimethyl hydrogen phosphorothioate, *O*-ester with *p*-hydroxy-*N,N*-dimethylbenzenesulfonamide

Common and Trade Names: Bo-Ana, Cyflee, Dovip, Famfos, Famophos, Fanfos, Warbex

Action: Insecticide

Properties: A crystalline powder, soluble in chlorinated hydrocarbons and polar solvents and soluble in water at 100 mg/L.

Field Applications and Formulations: Famphur is an organophosphorus systemic livestock insecticide that is either mixed into the feed or used as a pour-on treatment. It is not applied to forests or crops but is used primarily on cattle and sheep. Famphur is formulated in a liquid (13.2%) and a feed premix (33.3%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic sheep	U	U	U	400		63
Mouse	U	U	U	30		146
Rat	U	U	tech	36–62		11
European starling	U	U	U	4.2	(1.99–9.50)	225
Mallard	M	3–4	35	9.87	(5.88–16.60)	264
Red-winged blackbird	U	U	U	1.8	(1.0–3.2)	225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	2,730			11
Japanese quail	U	0.5	tech		69	(49–97)	122

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
European starlings	U	I	U			Free-living starling nestlings were dosed perorally with famphur daily from day 4 to 18; nestlings receiving 1.0 mg/kg per day did not have different growth rates from controls; however, prefledging weights were lower in treated birds	213
Mallard	U	0.3	tech		35		124
Ring-necked pheasant	U	0.3	tech		49	(40–61)	124

Effects of Field Applications and Field Tests on Wildlife: Laboratory analyses confirmed ChE inhibition and famphur residues in black-billed magpies found dead near areas where cattle were treated with famphur (Felton et al. 1981). Black-billed magpies were found dead on ranches where cattle were treated with famphur at recommended rates and released into pastures (Henny et al. 1985). Magpie mortality began on the first day of treatment and continued for more than 3 months. Mortality of red-tailed hawks was attributed to secondary mortality, and famphur persisted on cattle hair for more than 90 days (Henny et al. 1985).

Barn owls fed Japanese quail given a total of 1.0 mg famphur over a 3-day period developed secondary organophosphate poisoning (Hill and Mendenhall 1980).

An adult bald eagle was recovered unable to fly and later died during therapy. The eagle had 85% brain ChE inhibition and residues of famphur in the stomach contents (Franson et al. 1985).

Persistence and Hazard Evaluation: Famphur is a systemic livestock insecticide used on cattle and sheep. It is moderately to highly toxic in mammals and extremely toxic to birds through both acute oral and subacute dietary exposure. Although famphur is applied to livestock and not crops, it has caused deaths of black-billed magpies, American robins, and red-tailed hawks. Field evidence, confirmed by laboratory analyses and experimental work, demonstrates that famphur has been the causative agent in a number of avian die-offs. This livestock insecticide has the potential to cause not only direct mortality but also secondary poisoning to predatory birds. Because of its high avian toxicity and both field and experimental evidence demonstrating primary and secondary poisoning of birds, famphur should be considered hazardous to birds in areas where cattle are treated with this insecticide. More research on the extent of avian mortality and routes of exposure is needed.

Fenamiphos

CAS #22224-92-6

Toxicity Class: I

Use Class: V. Restricted

Chemical Name: Ethyl 4-(methylthio)-*m*-tolyl isopropylphosphoramidate

Common and Trade Names: Nemacur, Phenamiphos

Action: Nematicide, insecticide

Properties: Fenamiphos is a waxy brown semi-solid that is soluble in water at about 400 mg/L and soluble in most organic solvents.

Field Applications and Formulations: Fenamiphos is an organophosphorus systemic nematicide and insecticide with a broad spectrum of activity. It is applied to soil with or without incorporation, as a seed treatment, as a rare-root dip, and as a foliar spray. Major crops are peanuts and tobacco, with some use on corn, soybeans, and other field and vegetable crops. It is formulated as emulsifiable concentrates (3EC, 400 g/L) and granules (5, 10, and 15%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	10		285
Guinea pig	M	U	U	75–100		285
Mouse	F	U	tech	8.3		37
Rat	M	U	tech	8.1		37
	F	U	tech	9.6		37
	F	U	3EC	25		37
California quail	M	11	81	1.83	(1.12–3.01)	131
Mallard	M	3	81	1.68	(1.41–2.00)[a]	130
Northern bobwhite	M/F	A	tech	1.0	(0.7–1.3)	121
	M/F	A	15G	2.4	(1.2–4.6)	121
Ring-necked pheasant	M	3–4	81	0.5–1.0		131

[a]Range of highest dose producing no mortality to lowest dose producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	U	tech	73			37
	F	U	tech	84			37
	U	U	U			No symptoms of poisoning during a 2-year feeding trial at 3 ppm in the diet	285
Japanese quail	U	0.5	81		59	(46–75)	122
Mallard	M	13–15	81	23.8		(17.5–32.4)[a]	130

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: An estimated 400–500 cedar waxwings died in an area where fenamiphos was being used to control nematodes on pyracantha bushes. Birds had fed on mature pyracantha berries and blossoms, and fenamiphos was found in the gastrointestinal tracts of the birds examined. Information on application procedures was not available (Coon 1983, personal communication).

Persistence and Hazard Evaluation: Fenamiphos is a systemic nematicide and insecticide with contact activity. It is readily translocated in plants, oxidized to sulfoxide and sulfone metabolites, and is hydrolyzed to the desisopropyl sulfoxide (Chemagro Corporation 1971*e*). These metabolites are cholinesterase inhibitors, relatively persistent, and are detoxified by hydrolysis to phenolic metabolites (Chemagro Corporation 1971*e*; Vettorazzi 1976). Half-lives of the parent compound and metabolites range from about 3 to 6 months in most soils, and anaerobic conditions inhibit degradation (Chemagro Corporation 1971*e*). The predicted bioconcentration factor for fenamiphos is low (Kenaga 1980), and it is rapidly metabolized in animals (Chemagro Corporation 1971*e*).

Fenamiphos is extremely toxic to birds and mammals tested by acute oral exposure. Acute oral LD50's are as low as 0.5 mg/kg for ring-necked pheasants (Hudson et al. 1984), and dermal toxicity in birds and mammals is also high. Fenamiphos is a relatively persistent organophosphate and may be present in soils for an entire growing season (Chemagro Corporation 1971*e*). One wildlife die-off report suggested that the systemic activity of this nematicide may have resulted in bird poisoning through feeding on treated plants (Coon 1983, personal communication), although other incidences of wildlife die-offs in the literature have not implicated fenamiphos treatments. Its use on crops that are not wildlife foods may reduce wildlife exposure to this chemical.

Fenitrothion

CAS #122-14-5

Toxicity Class: III **Use Class:** VI

Chemical Name: *O,O*-Dimethyl *O*-(4-nitro-*m*-tolyl) phosphorothioate

Common and Trade Names: Accothion, Agrothion, Cekutrothion, Cyfen, Cytel, Dicofen, Dybar, Fenitox, Fenstan, Folithion, MEP, Novathion, Nuvanol, Sumanone, Sumithion, Verthion

Action: Insecticide, selective acaricide

Properties: A brownish-yellow liquid, soluble in most organic solvents and in water at 30 mg/L (Eto 1974).

Field Applications and Formulations: Fenitrothion is a contact and stomach-poison organophosphorus insecticide with some activity against red spider mites (Worthing 1979). It is used as a forest spray, in public health programs, and on some agricultural crops. Formulations include dusts (2–3%), emulsifiable concentrates (10, 50, 60, and 80%), fog (5%), granules (3%), and wettable powder (40%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mule deer	M	13	95	>727		131
Rat	M	A	tech	740	(612–895)	80
	F	A	tech	570	(463–701)	80
Mallard	M[a]	3–4	95	1,190	(392–3,610)	131
	F	3	95	1,662	(185–14,958)	131
Northern bobwhite	M	5		32.0	(17.4–59.0)	131
	M	2–3		27.4	(19.0–39.5)	131
	F	5		23.6	(12.8–43.5)	131
Ring-necked pheasant	M	3		55.6[a]	(28.9–107)	131
Sharp-tailed grouse	M	6–7		53.4	(42.4–67.3)	131

[a]Administered by stomach tube.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Mouse	U	U	U	>3,000			285
Rat	M	A	tech	300–400			80
	F	A	tech	300–400			
Japanese quail	U	0.5	95		652	(512–914)	122
Mallard	U	0.3	tech		2,482	(1,693–3,985)	124
	M	14–15	95	504		(370–686)[a]	130
Northern bobwhite	U	0.5	tech		157	(135–183)	124
Ring-necked pheasant	U	0.5	tech		453	(388–525)	124

Effects of Field Applications and Field Tests on Wildlife: Two applications of fenitrothion at 142 g actual/ha (2 oz/acre) to control spruce budworms did not result in significant bird, mammal, or amphibian mortality (Nash et al. 1971). One dead northern parula warbler was found in which brain ChE was severely depressed (Nash et al. 1971). Applications of up to 213 g AI/ha (3 oz/acre) were also reported to have no effect on forest-bird populations other than a temporary decline in bird activity (Buckner and McLeod 1977). Application rates of 213–284 g/ha (3–4 oz/acre) may produce mortality, primarily in nestlings and fledglings, while rates over 284 g/ha (4 oz/acre) may produce adult mortality. Species differences in sensitivity, likely related to exposure due to position within the forest canopy, have also been observed under field conditions (Buckner 1974). Applications of 213 and 426 g/ha (3.0 and 6.0 oz/acre) to rangelands have also resulted in bird mortality and decreases in bird numbers (McEwen 1982).

Persistence and Hazard Evaluation: Fenitrothion is an insecticide and selective acaricide that has been widely used to control forest insects, especially the spruce budworm (Buckner 1974). It is used on agricultural crops to control chewing and sucking insects and also to control mosquitos. It is a nonsystemic insecticide with residual activity. Forest applications of fenitrothion at 284 g/ha (4 oz/acre) resulted in a foliage residue half-life of about 4 days, a 70–85% loss of the initial amount within 2 weeks, and soil residues at nondetectable levels at 64 days (Yule and Duffy 1972). Coastal bermuda grass and corn treated with fenitrothion at rates up to 3.4 kg/ha (3 lb/acre) had residues of the parent compound and oxygen analog that declined to less than 1 ppm within 28 days (Leuck and Bowman 1969). At least nine different metabolites have been isolated from the degradation of fenitrothion, and its oxygen analog is toxicologically important. The predicted bioconcentration potential of fenitrothion is relatively low (Kenaga 1980).

Fenitrothion is of moderate toxicity to certain mammals, but is moderately to extremely toxic to birds, depending on the species. Acute oral LD50's in birds and dietary LC50's for some species indicate very high avian toxicity, and some neurotoxic effects have been described in rabbits (Lehotzky and Ungrary 1976). Results of extensive experimental field applications to forests show that lower application rates (below 213 g/ha; 3.0 oz/acre) have resulted in few significantly adverse effects on wildlife. However, at higher application rates, avian mortality, reductions in bird numbers, and decreases in bird activity have been observed.

Fensulfothion

CAS #115-90-2

Toxicity Class: I

Use Class: V. Restricted

Chemical Name: *O,O*-Diethyl *O*-[*p*-(methylsulfinyl)phenyl] phosphorothioate

Common and Trade Names: Dasanit, DMSP, Terracur-P

Action: Insecticide, nematicide

Properties: A yellow to brown liquid, soluble in most organic solvents, except aliphatics, and in water at 1,600 mg/L.

Field Applications and Formulations: Fensulfothion is an organophosphorus soil insecticide and nematicide with both systemic and contact activity. It has long residual action and is applied to soil before or at planting in a band or broadcast. The major field crop is tobacco, with corn, sorghum, and potatoes receiving moderately high applications. Formulations include an emulsifiable concentrate (6EC) and granules (5, 10, and 15%). It is also combined with disulfoton in spray concentrate and granular forms.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	10.5		33
	F	U	tech	2.2		33
	F	U	46SC	2.5		33
	F	U	63SC	2.0		33
	F	U	10G, 15G	12.0		33
California quail	M	9–10	90	1.68	(1.38–2.04)	131
	F	9	90	1.19	(0.94–1.51)	131
Mallard	F	5–7	90	0.75	(0.60–0.94)	131
Northern bobwhite	M/F	A	tech	1.2	(1.0–1.6)	121
	M/F	A	15G	2.4	(2.0–2.9)	121
Ring-necked pheasant	M	3	90	1.34	(1.06–1.68)	131
Sharp-tailed grouse	M	U	90	0.5–1.0		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	U	tech	30.0			33
	F	U	tech	3.5			33
	F	U	46SC	70.0			33
	M	U	63SC	39.8			33
	F	U	10G	>1,000			33
	U	U	U			490-day feeding trials at 1 ppm in the diet had no observable effects	285
Japanese quail	U	0.50	94		85	(62–116)	122
Mallard	U	0.30	94		43	(36–51)	124
	U	0.15	94		41	(32–55)	124
	F	15	90	2.86		(2.10–3.89)[a]	124
Northern bobwhite	U	0.30	94		35	(29–43)	124
Ring-necked pheasant	U	0.30	94		148	(119–179)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Canada geese, mourning doves, rock doves, and several species of ducks were among the unreported number of birds killed in a die-off. Brain ChE activity was inhibited 73 to 92% in the 6 specimens available for analysis, and fensulfothion was found in the gastrointestinal tracts of these birds. Whether the poisoning was accidental or intentional was not determined (Coon 1983, personal communication). Another incident involving treatment of a golf course with fensulfothion resulted in the death of at least 25 Canada geese (Stone 1979).

An application of fensulfothion, at an unreported rate, to a golf course resulted in the death of two wild turkeys and a third turkey becoming ill. Crop contents had fensulfothion concentrations of 812 and 1,190 mg/kg in the dead birds. The third turkey recovered with atropine therapy. The application was reported to have violated recommended use for this product (Nettles 1976).

A survey of agricultural areas where fensulfothion was being used recorded a total of 236 birds killed on a 122-ha (305-acre) area treated at rates of 1.1–2.3 kg/ha (1 to 2 lb/acre). The number of dead birds per ha ranged from 2 to 11 (0.8 to 4.4 birds/acre). Bird counts before and after fensulfothion was applied to pasture at 2.3 kg AI/ha (2 lb/acre) showed an average population reduction of 86% within 2 days after application (Mills 1973).

Persistence and Hazard Evaluation: Fensulfothion is a contact soil insecticide and nematicide that also has systemic activity when applied to foliage (Chemagro Corporation 1971*a*). It has long residual activity and may persist for long periods of time. Biological metabolites include the sulfone and oxygen analogs to the parent compound and the sulfone, all of which inhibit ChE and are at least as toxic as the parent compound (Food and Drug Administration 1982). Fensulfothion is one of the more persistent organophosphates, and residues in soils have been found beyond 900 days following application (Shella and Vasantharajan 1977). Incorporated into topsoil at 2.8 kg AI/ha (2.5 lb/acre), residues in pasture foliage were 4.8 mg/kg (dry weight) at 7 weeks following treatment (Solly et al. 1971). One laboratory study demonstrated the persistence of biological activity for 16 weeks (Harris 1969*b*).

Fensulfothion, and its three ChE inhibiting metabolites, are extremely toxic to birds and mammals. Acute oral and dermal LD50's are extremely low compared with other organophosphates. It is toxic to bees and fish (Thomson 1982) but has not been found to cause delayed neurotoxicity in hens (Food and Drug Administration 1982). Fensulfothion has been implicated in a number of wildlife die-offs, some of these involving applications to golf courses. In one study, bird kill averaged 1.9 birds/ha (0.75 birds/acre; Mills 1973). Application rates for nematode control are high, up to 45.2 kg/ha (40 lb/acre; Thomson 1982).

High application rates, relatively long persistence, and very high acute oral, subacute dietary, and dermal toxicity suggest a potential hazard to wildlife. Its application to crops that are not potential wildlife foods, such as tobacco, and careful field application of fensulfothion to nonwildlife areas may reduce its overall environmental risk. Careful evaluation of its residual effects, toxicity, and potential for wildlife exposure should be made prior to application.

Fenthion

CAS #55-38-9

Toxicity Class: III **Use Class:** VI

Chemical Name: *O,O*-Dimethyl *O*-[4-(methylthio)-*m*-tolyl] phosphorothioate

Common and Trade Names: Bay 29493, Baycid, Baytex, Entex, Lebaycid, S1752, Tiguvon

Action: Insecticide

Properties: A yellow, oily liquid soluble in most organic solvents and compatable with most other nonalkaline insecticides and fungicides. Fenthion's solubility in water is 50 mg/kg at 20°C.

Field Applications and Formulations: Fenthion is an organophosphorus insecticide used to control adult mosquitos, mosquito larvae, and flies. It is commonly used in public mosquito-abatement programs and is often applied in ultra-low volume (ULV). Fenthion is formulated as dust (3%), emulsifiable concentrate (4EC), granules (2%), and wettable powders (25, 40, and 50%; Thomson 1982).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rabbit	U	U	U	150		162
Rat	M	U	tech	255		183
	F	U	tech	298		183
California quail	M	6–7	99	15.0	(11.9–18.9)	131
Canada goose	M/F	U	99	12.0	(8.48–17.0)	264
Chukar	M/F	3	90	25.9	(15.8–42.7)	264
Duck, unspecified	U	U	U	15		32
European starling	U	U	U	5.3–17.8		228
House finch	M/F	U	90	10[a]	(14.6–35.1)	131
House sparrow	F	U	99	22.7	(14.6–35.1)	264
Japanese quail	F	3	99	10.6	(8.41–13.3)	264
Mallard	F	4	90	5.94	(4.28–8.23)	264
Mourning dove	M/F	U	99	2.68	(1.34–5.35)	264
	M/F	U	99	2.50[a]	(1.25–5.00)	131
Northern bobwhite	M	U	99	≤4.0		131
Red-winged blackbird	U	U	U	1.8	(1.0–3.2)	225
Ring-necked pheasant	F	7–24	99	17.8	(9.33–34.0)	264

[a]Administered using a stomach tube.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	U	tech	330			183
	F	U	tech	330			183
	F	U	0.479 kg/L (4 lb/gal)	500			183
American black duck	U	A	U			17 ppm in diet on days 6–11 affected enzyme activity in salt glands	59
Common grackle	U	U	97.1		<30–57		98
Japanese quail	U	0.5	tech		132	(106–169)	122
Northern bobwhite	U	0.3	tech		30	(21–41)	124
Mallard	U	0.3	tech		231	(108–395)	124
	M	10–11	99	44.0		(22.0–88.0)[a]	130
Ring-necked pheasant	U	0.3	tech		202	(154–254)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Aerially applied to flooded meadows at 52 g AI/ha, fenthion did not accumulate to detectable (>0.01 ppm) concentrations in chorus frogs (*Pseudacris triseriata*; Powell et al. 1982). The same application rate did not affect reproductive parameters of red-winged blackbirds, although food abundance was reduced (Powell 1984).

Black-billed magpie mortality was observed in the proximity of cattle feedlots where cattle had been dermally treated with fenthion up to 4–5 months previous to the incident. Fenthion was detected in magpie gizzards (Hanson and Howell 1981).

About 125 ducks were killed in an area where rock doves were being poisoned with fenthion. Fenthion was found in the gastrointestinal tract of some birds, and three mallards and three wigeons showed ChE inhibition (60–80%) (Coon 1983, personal communication).

Another field die-off resulted from an aerial application of 92.3 g AI fenthion/ha (1.3 oz/acre) to 600 ha (1,500 acres) for mosquito control, which killed an estimated 5,000–25,000 birds. (Seabloom et al. 1969; Seabloom et al. 1973).

An aerial application by helicopter, of 2.4 times the recommended rate of 92.3 g/ha (1.3 oz/acre) was believed to have resulted in an estimated kill of more than 1,000 house sparrows, mockingbirds, and other species (Hazard Evaluation–EPA 1981).

Aerial applications of 46.9–53.2 g AI/ha (0.66 to 0.75 oz/acre) resulted in 185 dead birds and mammals found after several sprayings over a 2-year period. Some secondary poisoning was also reported (DeWeese et al. 1981).

Several species of wading birds were found dead in an area sprayed with 0.1 kg fenthion/ha (0.1 lb/acre). Serum and brain cholinesterase activity were depressed (>50% inhibition) in samples from dead birds (Zinkl et al. 1981).

Adverse effects on birds, mammals, or reptiles were not observed in upland areas sprayed with fenthion at 0.1 kg/ha (0.1 lb/acre). Cholinesterase inhibition and adverse effects were reported for shorebirds and red-winged blackbirds exposed to the same rate (Elder and Henderson 1969).

An experiment that simulated a field exposure of black-crowned night-herons to fenthion in a shallow-wading environment, at ten times the normal application rate, resulted in significant plasma (BChE) cholinesterase inhibition (Smith et al. 1986).

Persistence and Hazard Evaluation: Fenthion is an insecticide that is commonly used to control mosquitos and other insect pests. It is also applied to livestock and buildings for residual insect control. It is rapidly degraded into five metabolites, the primary ones being fenthion sulfoxide and and sulfone (Menzie 1974). It is especially subject to hydrolysis under alkaline conditions (Berg 1982; Thomson 1982); its solubility in water is 55 mg/kg (Kenaga 1980); and its predicted bioconcentration factor indicates a probable low potential for bioconcentration in the environment.

When sprayed on rice, disappearance of fenthion was rapid and about 10% of extractable metabolites remained after 6 h (Menzie 1974). Fenthion applied experimentally at rates of 0.6, 1.1, and 2.3 kg/ha (0.5, 1.0, and 2.0 lb/acre) had residues less than 0.1 mg/kg after 14 days in corn and after 21 days in bermuda grass (Lueck and Bowman 1968*b*).

This pesticide has a relatively low to moderate environmental persistence compared with other organophosphates. Its predicted bioconcentration factors are less than 100, and it is rapidly oxidized into its environmental metabolites.

Fenthion is moderately toxic to mammals and extremely toxic to most birds with acute oral LD50's as low as 1.8 mg/kg for some species (Schafer 1972). Dermal toxicity in bird species is also high (Hudson et al. 1979).

Fenthion is toxic to bees and some aquatic life forms and should not be sprayed in areas containing fish, shrimp, crabs, or crayfish (Thomson 1982). Because fenthion is used to control larval and adult mosquitos, wetland species, including waterfowl and wading birds, could be exposed. Black-crowned night-herons experimentally exposed to fenthion-treated water had significantly depressed plasma ChE activity at ten times the normal application rate, although birds were likely only exposed dermally (Smith et al. 1986). Adult American black ducks fed mash containing 21 ppm fenthion had brain and salt gland AChE activities that were inhibited (44–61% and 14–36%, respectively); however, osmoregulatory function was not markedly affected (Rattner et al. 1983). Several suspected and confirmed wildlife die-offs have been attributed to field applications of fenthion. Recommended application rates should not be exceeded and wildlife exposure should be carefully evaluated and minimized prior to spraying.

Fonofos

CAS #944-22-9

Toxicity Class: I **Use Class:** II. Restricted

Chemical Name: *O*-Ethyl *S*-phenyl ethylphosphonodithioate

Common and Trade Names: Dyfonate

Action: Soil Insecticide

Properties: A pale-yellow liquid, miscible in organic solvents with a low water solubility of 13 mg/L at 21°C (Office of Pesticide Programs 1976).

Field Applications and Formulations: Fonofos is an organophosphorus insecticide usually applied to soils at a depth of 5.1–7.6 cm (2–3 in.) by discing at cultivation, or it is applied ahead of the press wheel at the time of planting. Corn receives the greatest volume of treatment, with other crops receiving relatively minor applications. It is also combined with pebulate for insect and weed control in tobacco. Fonofos is formulated as granules (10 and 20%) and as an emulsifiable concentrate (0.479 kg/L; 4 lb/gal).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	U	8–17.5		11
European starling	U	U	U	42		225
Mallard	M	3–4	94.3	16.9	(13.4–21.3)	131
Northern bobwhite	M/F	A	tech	12	(10–14)	121
	M/F	A	20G	14	(12–17)	121
Red-winged blackbird	U	U	U	10	(5.6–18)	225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Guinea pig	U	U	U	278			285
Rabbit	U	U	U	147			146
	U	U	U	25			11
Japanese quail	U	0.5	93		290	(224–377)	122
	U	0.5	44.6		284	(247–326)	122
Mallard	U	0.3	93		1,225	(889–1,773)	124
Northern bobwhite	U	0.5	93		133	(105–195)	124
Ring-necked pheasant	U	0.3	93		270	(239–306)	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Fonofos is applied to soils in both granular and emulsifiable concentrate formulations. It has been reported to persist in soil for about 56 days (Worthing 1979) and is normally applied at a rate of 0.6–4.5 kg actual/ha (0.5–4 lb actual/acre; Thomson 1982). Applied at 11.3 kg/ha (10 lb/acre), one-half of the original amount remained after 28 days (Schultz and Lichtenstein 1971). Under laboratory conditions, the half-life of fonofos was 6–7 months, and its mobility in soil was insignificant (Lichtenstein et al. 1977). Applied at rates of 5.7 and 11.3 kg/ha (5 and 10 lb/acre) in two different formulations, it was determined that emulsifiable concentrate residues in soil were greater than those for the granular formulation (Saha et al. 1974). These results showed that after 4 months 33–35% and 52–64% of the granular treatment remained from low and high application rates, and 38–41% and 50–71% of the emulsifiable treatment remained from low and high levels, respectively (Saha et al. 1974). In another study, 40–48% of the initially recovered levels of fonofos remained in soils after 4 months (Kahn et al. 1976). The above results indicate that fonofos is one of the more persistent organophosphates. Because it is nearly insoluble in water, its predicted bioconcentration is likely high compared with other organophosphates. Its persistence appears to be highest when applied at higher rates in an emulsifiable formulation.

A limited amount of information is available on the toxicity of fonofos. Tests on some birds and mammals suggest high acute oral toxicity. Considering its very high field use and toxicity and its relatively long persistence, it would be reasonable to expect that this chemical could cause wildlife mortality. In actuality, field applications of fonofos resulting in wildlife die-offs have not been found in the published literature. Fonofos has been reported to be hazardous to fish and wildlife (Thomson 1982). Like terbufos, another soil insecticide, the apparent potential for wildlife die-offs to occur as a result of the use of this chemical has either not been realized or has not been reported. Complete incorporation of the chemical into the soil probably minimizes wildlife exposure.

Formetanate

CAS #22259-30-9

Toxicity Class: I **Use Class:** VI

Chemical Name: Methylcarbamic acid, ester with *N'*-(*m*-hydroxyphenyl)-*N*,*N*-dimethyl formamidine

Common and Trade Names: Carzol, Dicarzol

Action: Acaricide, insecticide

Properties: A yellow crystalline solid soluble in water at less than 1,000 mg/L. It is formulated as the hydrochloride (HCl), which is a white crystalline powder soluble in water at more than 500,000 mg/L.

Field Applications and Formulations: Formetanate HCl is a contact acaricide and insecticide used to control mites, thrips, and many other plant insects. Its major use is on apples and citrus, and it is formulated as soluble powders (20, 25, and 92%) and as a wettable powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	19		285
Mouse	U	U	U	18		285
Rat	U	U	U	20		11
Chicken	U	U	U	22		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			2-year chronic oral level of 200 ppm in the diet showed no "significant abnormality"	285

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	>10,200			285
Rat	U	U	U	>5,600			285
Japanese quail	U	0.5	93		993	(673–1,465)	122
Duck, unspecified	U	U	U		6,810[a]		285
Northern bobwhite	U	U	U		>4,640[a]		285
Ring-necked pheasant	U	U	U		>4,640[a]		285

[a]Formetanate hydrochloride, CAS #23422-53-9.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Formetanate, formulated as the hydrochloride, has low agricultural field use. It has been described as persistent in some soils and nonpersistent in others. Half-lives reported have ranged from 2 days (Kuhr and Dorough 1976) to less than 28 days (Food and Drug Administration 1982). Applied to citrus and apples, the majority of the parent compound was still present at 28–54 days after application (Food and Drug Administration 1982). Formetanate HCl is not readily absorbed or translocated, and toxicologically important residues include the parent compound and its free base (Food and Drug Administration 1982).

Formetanate HCl is extremely toxic (acute oral exposure) to mammals and birds used in its toxicological evaluations. Its mammalian acute dermal and avian subacute dietary toxicities are much lower. Although extremely toxic to certain species, it is likely that limited field use of this insecticide reduces potential wildlife exposure. Moreover, the subacute dietary toxicity of formetanate HCl to wildlife species is low.

Isophenphos

CAS #25311-71-1

Toxicity Class: I **Use Class:** V. Restricted

Chemical Name: *O*-Ethyl hydrogen isopropylphosphoramidothioate, *O*-ester with isopropyl salicylate

Common and Trade Names: Amaze, Isofenphos, Oftanol

Action: Insecticide

Properties: A yellow-brown liquid, soluble in water at 20 mg/L and hydrolyzed under alkaline conditions.

Field Applications and Formulations: Isophenphos is a selective organophosphorus soil insecticide with contact and stomach-poison activity. It is used primarily on corn and to a lesser extent on turf to control corn rootworm, onion maggots, white grubs, and other soil pests. It is formulated as an emulsifiable concentrate (6EC), granules (5 and 20%), seed dressing powder, and wettable powder (40%). Isophenphos is also used in combination with thiram.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	91.3–127		285

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	tech	28–38		11
Northern bobwhite	M/F	A	tech	13	(10–16)	121
	M/F	A	15G	19	(15–23)	121

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	tech	162–315			11
Japanese	U	U	U		5–12.5		285
quail	U	0.5	73		299	(256–345)	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Isophenphos is a selective contact and stomach-poison insecticide used primarily on corn and turf to control soil insects. It is applied as a preplant or preemergence soil treatment (Thomson 1982), and few data are available on the persistence and environmental fate of this insecticide. The potential bioconcentration factor of isophenphos, predicted from water solubility, is relatively low.

Isophenphos has moderate to high acute oral toxicity in the laboratory rat and mouse, respectively. Acute oral toxicity for technical grade and granular formulations of isophenphos were very high for northern bobwhites (Hill and Camardese 1984). The dietary LC50 for Japanese quail also indicates high subacute toxicity for that species (Worthing 1979). However, the few toxicity data available do not allow extrapolation to predict its overall avian and mammalian toxicity. Moreover, the fate of isophenphos in the environment is largely unknown. More information on environmental fate and wildlife toxicity of this chemical is needed, especially because of its apparent high acute toxicity.

Malathion

CAS #121-75-5

Toxicity Class: III **Use Class:** III

Chemical Name: Diethyl mercaptosuccinate, *S*-ester with *O,O*-dimethyl phosphorodithioate

Common and Trade Names: Calmathion, Carbophos, Celthion, Chemathion, Cythion, Detmol, Emmatos, Emmatos Extra, Formal, Fyfanon, Hilthion, Karbofos, Kop-Thion, Kypfos, Malamar, Malaphele, Malaphos, Malathion ULV Concentrate, Malatol, Malmed, Maltox, Mercaptothion, MLT, Sumitox, Vegfru Malatox, Zithiol

Action: Insecticide, acaricide

Properties: A clear amber liquid, soluble in water at 145 mg/L and miscible in most organic solvents.

Field Applications and Formulations: Malathion is a broad-spectrum organophosphorus insecticide and acaricide applied to several types of crops. It is used to control mosquitos and grasshoppers and is widely used on rice, wheat, alfalfa, and soybeans. Malathion is formulated in aerosols (4%), baits (5 and 10%), emulsifiable concentrates (4, 5, 7, and 9.7EC), granules, wettable powders (25 and 50%), and in ultra-low volume concentrates.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	720–4,060		146
Rat	M	A	tech	1,375		80
	F	A	tech	1,000		80
European starling	U	U	U	Not toxic at 100 mg/kg		225
Horned lark	M/F	A	95	403	(247–658)	131
Mallard	F	3	95	1,485	(1,020–2,150)	131
Red-winged blackbird	U	U	U	Not toxic at 100 mg/kg		225
Ring-necked pheasant	F	3	95	167	(120–231)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			"No effect" chronic dietary level of 100 ppm in the diet at 90 days	146
Rabbit	U	U	U	4,100 (24 h)			146
Rat	U	U	U	>4,000			146
	U	U	U			No observed gross effects at dietary levels of up to 5,000 ppm in the diet for 104 weeks	11
Japanese quail	U	0.5	95		2,968	(2,240–3,932)	122
Mallard	U	0.5	95		>5,000	No mortality to 5,000 ppm	124
Northern bobwhite	U	0.5	95		3,497	(2,959–4,117)	124
Ring-necked pheasant	U	0.3	95		2,639	(2,220–3,098)	124
Mallard eggs						LC50's determined for external applications were less than 11 times the maximum field application level; some teratogenic effects observed	126

Effects of Field Applications and Field Tests on Wildlife: Malathion applied at 0.6 to 1.1 kg/ha (0.5 to 1.0 lb/acre) resulted in no observed mortality of wild birds in one study conducted, and bird counts after spraying were either higher or nearly the same as before spraying (Black and Zorb 1967). Applied at rates of 852–1140 g/ha (12–16 oz/acre) to fields containing caged quail, evidence of mortality or population changes of wild birds were not observed (Parsons and Davis 1971).

Malathion was aerially applied to a forested watershed at the rate of 0.81 kg/ha, and birds reacted to the spraying for 2 days without lasting effects. No effects on reptiles and amphibians were observed; however, populations of mice and chipmunks were reportedly reduced by at least 30% (Giles 1970).

A review of malathion application effects to rangelands for grasshopper control at rates of 426–568 g/ha (6.0–8.0 fl oz/acre) concluded that wildlife mortality was generally not observed, although a reduction in bird numbers did occur under some conditions (McEwen 1982).

Persistence and Hazard Evaluation: Malathion is a broad-spectrum insecticide and acaricide that acts as a contact and stomach poison. It degrades rapidly in soils, and losses of 50 to 90% in 24 h have been reported (Konrad et al. 1969). Metabolism and degradation are through several different pathways, and one metabolic intermediate, malaoxon, is known to be more toxic than the parent compound, but very transitory (Von Rumker et al. 1974). Tadpoles exposed to 5 mg/L malathion through a continuous-flow apparatus did not bioaccumulate levels that were toxic when fed to 2-week-old mallard ducklings in a single meal (Hall and Kolbe 1980). The predicted bioconcentration factor for malathion is low.

Malathion has moderate to slight acute oral toxicity to birds and mammals; however, it is toxic to bees, fish, and some aquatic organisms (Von Rumker et al. 1974; Mulla et al. 1979; Thomson 1982). It is widely used on agricultural crops, rangelands, and in wetlands, but there are no published reports of wildlife die-offs that can be attributed to the use of malathion. Its persistence and toxicity to birds and mammals is relatively low. However, malathion's toxicity has been reported to be potentiated by EPN treatment (Murphy 1969), and the interaction of these and other pesticides is not fully understood.

Methamidophos

CAS #10265-92-6

Toxicity Class: I

Use Class: III. Restricted

Chemical Name: *O,S*-Dimethyl phosphoramidothioate

Common and Trade Names: Acephatemet, Hamidop, Methamidofos Estrella, Monitor, Tahmabon, Tamaron

Action: Insecticide, acaricide

Properties: The technical product is an off-white crystalline solid, readily soluble in water and alcohols.

Field Applications and Formulations: Methamidophos is a systemic organophosphorus insecticide and acaricide that also acts as a contact and stomach poison with residual effectiveness. It has a broad spectrum of activity and major use crops include potatoes and tomatoes, with several other crops receiving minor use. Methamidophos is formulated as emulsifiable concentrates (4 and 6EC), granules (5%), and a wettable powder (25%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	U	U	U	30–50		263
Mouse	U	U	U	30		263
Rabbit	U	U	U	10–30		263
Rat	U	U	75% tech	18–21		11
Dark-eyed junco	U	A	75% tech	8		293
Mallard	M	3	74.8	8.48[a]	(6.73–10.7)	131
Northern bobwhite	U	U	U	57.5		263

[a]Administered by stomach tube.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			"No effect" chronic dietary level of 0.75 ppm in the diet daily at 2 years	285
Rabbit	U	U	75% tech	118			11
Rat	U	U	U	50–110			285
			U			At 0.1 mg/kg per day terata were observed; at 0.3 mg/kg per day, two of 63 pups developed club hand	75
Japanese quail	U	0.5	73		92	(73–116)	122

Effects of Field Applications and Field Tests on Wildlife: An unreported number of house sparrows and at least one killdeer were found dead near a cabbage field sprayed with methamidophos. Gastrointestinal tracts from 5 sparrows and the killdeer contained methamidophos, and brain cholinesterase was inhibited 39–75% in 4 of the 5 sparrows examined (Coon 1983, personal communication).

Persistence and Hazard Evaluation: Methamidophos is a systemic insecticide and acaricide that is also an environmental metabolite of acephate, another organophosphate insecticide. The initial biological half-life for methamidophos on tomato fruit and leaves is 7–10 days; however, this rate decreased to yield a half-life of about 6 weeks (Horler et al. 1974). Half-lives of methamidophos, as a hydrolysis product of acephate applied at 0.6 g AI/L (0.5 lb/100 gal), ranged from 9 to 14 days on citrus foliage (Nigg et al. 1981). Methamidophos degrades rapidly in the environment and has half-lives of 2–6 days in silt and sandy soil, respectively (Food and Drug Administration 1982). High water solubility suggests the predicted bioconcentration of methamidophos is likely low. The overall persistence of methamidophos in the environment also appears to be low. Methamidophos is extremely toxic to birds and mammals based on existing toxicity data. For dark-eyed juncos dosed with acephate and methamidophos, acute oral LD50's were 106 and 8 mg/kg, respectively (Zinkl et al. 1981). Few other wildlife species have been used in the toxicological evaluation of this insecticide. Domestic use of methamidophos is moderately high; however, because it is a hydrolysis product of acephate, the potential exposure to wildlife and the environment must also be considered before using acephate. Moreover, a significant potentiation of acute oral toxicity was observed in rats when methamidophos was combined with malathion (FAO/WHO 1976). Its high acute toxicity, moderately high field use, and possible interactions with other pesticides suggest careful evaluation of possible wildlife exposure prior to application. More information on the toxicity of methamidophos to wildlife species and the interaction of this chemical with other pesticides is needed.

Methidathion

CAS #950-37-8

Toxicity Class: II

Use Class: IV. Restricted

Chemical Name: *O,O*-Dimethyl hydrogen phosphorodithioate, *S*-ester with 4-(mercaptomethyl)-2-methoxy-Δ^2-1,3,4-thiadiazolin-5-one

Common and Trade Names: Somonic, Somonil, Supracide, Ultracide

Action: Insecticide, acaricide

Properties: Colorless crystals, soluble in most organic solvents and in water at 240 mg/L. Methidathion is hydrolyzed under alkaline conditions and is readily metabolized by plants.

Field Applications and Formulations: Methidathion is a nonsystemic broad-spectrum organophosphorus insecticide and acaricide used on several agricultural crops. Sunflowers, alfalfa, and oranges receive the highest applications, and formulations include emulsifiable concentrates (2EC, 40% EC), ultra-low volume (ULV 250), and wettable powders (20 and 40%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	25–68		146
Rat	U	U	tech	44		11
	U	U	0.240 kg/L (2 lb/gal)	65		11
Canada goose	M/F	A	98.2	8.41	(4.20–16.8)	131
Chukar	M/F	12–24	98.2	225	(178–283)	131
Mallard	F	3–4	98.2	23.6	(16.5–33.8)	131
Ring-necked pheasant	F	4	98.2	33.2	(17.3–63.5)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Bull calves	M	I	U			Calves were dosed daily at rates of 0.0, 0.5, 1.0, and 2.0 mg/kg live weight; 3 of the 5 animals at 2.0 mg/kg per day died after 12, 33, and 34 days; food consumption and blood ChE activity were inversely related to methidathion intake	210
Rabbit	U	U	tech	200			11
			0.240 kg/L (2 lb/gal)	640			11
Rat	U	U	U			"No effect" chronic dietary level of 0.2 mg/kg per day at 2 years	285
Rhesus monkey	U	U	U			"No effect" chronic dietary level of 0.25 mg/kg per day at 2 years	285
Japanese quail	U	0.5	99		980	(793–1,193)	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Methidathion is a broad-spectrum insecticide and acaricide with stomach-poison and contact activity. It degrades rapidly in soil, with half-lives of 2–3 weeks (Getzin 1970; Food and Drug Administration 1982). In fumigated soils, 50% of the initial insecticide remained after 16 weeks, and degradation was considered to be primarily due to microorganisms (Getzin 1970). In plants, methidathion is rapidly metabolized to CO_2, and its oxygen analog is not the major metabolite (Cassidy et al. 1969; Vettorazzi 1976). The oxygen metabolite, more acutely toxic than the parent compound (Bull 1968; Walter-Echols and Lichtenstein 1978), has not been identified in animals. The bioconcentration potential of methidathion has been reported as "low" (Food and Drug Administration 1982), and its predicted BCF calculated from water solubility, is small.

Methidathion has high acute oral toxicity to birds and mammals and moderately high field use. It has not been shown to cause delayed neurotoxic effects, and it is reportedly not teratogenic at the levels tested (Vettorazzi 1976). However, both the parent compound and oxygen analog are potent cholinesterase inhibitors and field use is moderately high compared with other organophosphate insecticides. There have been no reported wildlife problems resulting from the use of this compound, although it is toxic to bees and fish (Thomson 1982). Specific crop usage patterns may minimize exposure to wildlife species, and careful evaluation of wildlife use of treated areas should be made prior to application.

Methiocarb

CAS #2032-65-7

Toxicity Class: I **Use Class:** VI. Restricted

Chemical Name: 4-(Methylthio)-3,5-xylyl methylcarbamate

Common and Trade Names: Draza, Mercaptodimethur, Mesurol, Metmercapturon

Action: Insecticide, acaricide, molluscicide

Properties: A white crystalline powder, soluble in most organic solvents and in water at 27 mg/L.

Field Applications and Formulations: Methiocarb is a broad-spectrum, nonsystemic carbamate insecticide also effective against mites, slugs, snails, and used as a bird repellent. Its primary agricultural use is on oranges and other citrus. Methiocarb is formulated as bait (2%), dust (3%), pellets (4%), and in wettable powders (50 and 75%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	U	U	U	40		285
Rat	U	U	tech	15–35		11
European starling	U	U	U	13		225
Horned lark	M/F	A	98	31.4	(20.4–48.4)	131
Mallard	F	3–4	98	12.8	(7.37–22.4)	131
Red-winged blackbird	U	U	U	4.6	(2.7–6.9)	225
Ring-necked pheasant	F	3–6	98	270		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	tech	>2,000			11

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	U	U	350–400			285
	U	U	U			1.67-year feeding study with no symptoms noted at 100 ppm in the diet	285
Japanese quail	U	0.5	97		1,342	(1,048–1,719)	122
	U	0.5	50		1,182	(966–1,446)	122
Mallard	U	0.3	97		4,113	(2,817–7,504)	124
	U	0.15	97		1,071	(808–1,405)	124
	U	0.3	50		2,082	(1,482–3,139)	124
	U	0.15	50		929	(680–1,245)	124
Ring-necked pheasant	U	0.3	97		>5,000	No mortality to 5,000 ppm	124
	U	0.3	50		3,849	(3,318–4,488)	124
Birds						Methiocarb appeared to be noncumulative when measured by an index of chronicity	226

Effects of Field Applications and Field Tests on Wildlife: Methiocarb wettable powder, applied to grape vineyards at 2.3 kg/ha (2 lb AI/acre), was evaluated in terms of its bird repellency and hazard. It was concluded that methiocarb was effective in repelling birds, and searches made for dead or affected birds on 10–30% of the treated area showed that 10 passerines had symptoms of carbamate poisoning. All 10 birds recovered within 4 h and left the vineyard, and there were no dead birds found (Hothem et al. 1981).

Other studies of the effectiveness of methiocarb to repel birds in sprouting corn, blueberries, wild rice, and other crops have generally concluded that it is relatively effective. None of the published reports noted bird mortality resulting from methiocarb use; however, intensive dead bird surveys were not reported in conjunction with most efficacy testing (West et al. 1969; Stone et al. 1974; Moulton 1979).

Persistence and Hazard Evaluation: Methiocarb is an insecticide, acaricide, molluscicide, and bird repellent. Although currently it has relatively low field use, the market for this pesticide is reported to be expanding (Food and Drug Administration 1982). Methiocarb is hydrolyzed in alkaline soils, while in acidic soils it is oxidized to the sulfoxide prior to hydrolysis (Menzie 1978). Half-lives in soils range from 4 days at pH 7.6 to more than 56 days at pH 4.1 (Menzie 1978). In plants, the primary degradation route is oxidation (Menzie 1978). The parent compound, the sulfoxide metabolite, and the sulfone metabolite all have anticholinesterase activity (Food and Drug Administration 1982). The predicted bioaccumulation potential of methiocarb is low (Food and Drug Administration 1982).

Methiocarb has high acute oral toxicity to birds and mammals but has a moderately low subacute dietary toxicity to bird species tested. It is also toxic to fish, bees, and earthworms (Thomson 1982). Available information suggests relatively low teratogenic, oncogenic, neurotoxic, and mutagenic potentials (Food and Drug Administration 1982). Although the published literature contains no reports of methiocarb applications resulting in wildlife die-offs, there is currently relatively low field use of this chemical. Possible increases in use could increase wildlife exposure, and its use in slug and snail control would expose birds that utilize those species for food. Several field tests have confirmed methiocarb's effectiveness as a bird repellent while not causing any apparent avian mortality. Hothem et al. (1981) concluded that the low application rate of 2.3 kg AI/ha (3.1 kg Mesurol/ha) provided for a wide margin of safety for wild birds.

Methomyl

CAS #16752-77-5

Toxicity Class: I

Use Class: I. Restricted

Chemical Name: Methyl *N*-[(methylcarbamoyl)oxy]thioacetimidate

Common and Trade Names: Griffin Nu-Bait II, Lannate, Nudrin

Action: Insecticide, nematicide

Properties: A white crystalline solid, soluble in water at 58,000 mg/L.

Field Applications and Formulations: Methomyl is a systemic carbamate insecticide and nematicide with a broad spectrum of activity. It is used as a foliar and soil treatment and has contact and stomach-poison activity. Soybeans, sweet corn, and cotton receive major applications, and it has minor use on several other crops. Methomyl is formulated as a bait (1.25%), liquid (0.216 kg/L; 1.8 lb/gal), and a water-soluble powder (90%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mule deer	M	13	90	11.0–22.0		131
Rat	M	U	U	17		11
	F	U	U	24		11
European starling	U	U	U	42		225
Mallard	M	8–24	90	15.9	(11.4–22.0)	131
Red-winged blackbird	U	U	U	10	(5.6–18)	225
Ring-necked pheasant	M	3–4	90	15.0	(10.0–22.3)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	>5,000			285
Japanese quail	U	0.5	tech		3,436	(1,992–5,928)	122
Mallard	U	0.3	tech		2,883	(2,000–4,572)	124
Northern bobwhite	U	0.5	tech		~1,100		124
Ring-necked pheasant	U	0.3	tech		1,975	(1,641–2,374)	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Methomyl is a widely used insecticide and nematicide applied to several types of crops. It has systemic activity in plants and is absorbed from the soil. Under field conditions, 1.8% of the initial amount of methomyl applied to soil remained after 1 month (Harvey and Pease 1973). Biological activity of methomyl applied to soil disappeared after 16 weeks (Harris 1969*a*), and residues of foliar treatments to cotton may be depleted within 8 days (Bull 1974). The predicted bioconcentration factor for methomyl is very low.

Methomyl is one of the more acutely toxic carbamates. It is extremely toxic to birds and mammals through acute oral exposure; however, its subacute toxicity appears lower. Acute dermal toxicity to rabbits is also low. Although methomyl is widely used and has high acute toxicity, published accounts of methomyl causing adverse effects on wildlife are lacking. The moderate to low environmental persistence and low subacute toxicity may reduce its overall hazard to wildlife; however, it is apparent that methomyl is acutely toxic to wildlife species and exposure to wildlife should be avoided.

Methyl Parathion

CAS #298-00-0

Toxicity Class: I

Use Class: I.[1] Restricted

Chemical Name: *O,O*-Dimethyl *O*-(*p*-nitrophenyl) phosphorothioate

Common and Trade Names: Bladan-M, Dalf, Dimethyl parathion, Folidol-M, Metacide, Metafos, Methyl nitran, Metron, Nitrox, Partron-M, Penncap-M, Tekwaisa, Wofatox

Action: Insecticide

Properties: White crystalline powder that is soluble in most organic solvents and in water at 57 mg/L.

Field Applications and Formulations: Methyl parathion is the most widely used organophosphate pesticide in the United States. It is applied to a large number of agricultural crops, irrigated pastures, forests, and other areas to control mosquitos and other insects. It is a restricted-use pesticide in the United States, and the major-use agricultural crop is cotton. Methyl parathion is formulated in dusts (2.5 and 5%), emulsifiable concentrates (2, 4, 6, and 8EC), wettable powders (20 and 40%), and it is often combined with other insecticides.

[1]Parathion and methyl parathion were combined in field-use surveys.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	32		146
Rat	M	A	tech	14		80
	F	A	tech	24		80
	U	U	tech	9–25		11
American kestrel	M/F	>8	98.2	3.08	(2.29–4.14)	217
European starling	U	U	U	7.5		225
Mallard	M	3	80	10.0	(6.12–16.3)	131
	F	4–5	80	60.5	(18.2–201)	131
	F	18	80	6.6	(4.4–9.9)	131
Northern bobwhite	M	A	80	7.56	(5.70–10.0)	131
Red-winged blackbird	U	U	U	10	(5.6–18)	225
	F	A[a]	80	23.7	(17.1–32.9)	131
Ring-necked pheasant	F	2	80	8.21	(5.69–11.9)	131

[a]Birds may have been in reproductive condition.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	300–400			11

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	1,270			146
Rat	M	A	tech	67			80
	F	A	tech	67			80
	U	U	U			Chronic oral 5 ppm in the diet with "no effect" at 90 days	146
Common grackle	U	A	96.7		240		98
Japanese quail	U	0.5	80		69	(61–78)	122
Mallard	F	I	80	53.6		(39.3–72.9)	130
	U	0.15	80		336	(269–413)	124
	U	0.3	80		682	(541–892)	124
Northern bobwhite	U	0.5	80		90	(73–111)	124
Ring-necked pheasant	U	0.3	80		91	(77–107)	124

Effects of Field Applications and Field Tests on Wildlife: A field experiment was conducted using 13 aerial applications of methyl parathion at 1.1 kg/ha (1 lb/acre) with toxaphene during one season. Direct mortality of northern bobwhites and cottontail rabbits was not observed; however, brain ChE was depressed 9–68% in bobwhites and 7–32% in cottontails (Smithson and Sanders 1978). Soybean fields were treated with methyl parathion and methomyl and 10 days later with methyl parathion and toxaphene. This resulted in 11 dead quail after the second application (Hazard Evaluation–EPA 1981). In another incident, about 1,200 Canada geese were found dead, and both parathion and methyl parathion were found in ingesta (Coon 1983, personal communication).

Three applications of methyl parathion at 0.6 and 3.4 kg/ha (0.5 and 3 lb/acre) were made to pens containing pheasants. The 0.6 kg/ha (0.5 lb/acre) rate resulted in one death in 42 birds. At the rate of 3.4 kg/ha (3 lb/acre), 11 of 42 birds died, half of the birds were sick, and effects lasted 3 weeks (Zorb 1967*b*).

Methyl parathion administered to American kestrels by stomach gavage produced brain and plasma ChE inhibition, hyperglycemia, elevated plasma corticosterone, and hypothermia. The toxicity of methyl parathion was intensified by cold (Rattner and Franson 1984).

Persistence and Hazard Evaluation: Methyl parathion is a broad-spectrum insecticide and acaricide that is used on a number of different kinds of agricultural crops, as well as on rangelands and forests. It is by far the most widely used agricultural chemical in terms of acres treated per year. It is also used as a mosquito larvicide and in abatement programs for controlling adult mosquitos.

In the United States it is a restricted-use pesticide. Methyl parathion has been reported to be generally less hazardous than parathion (diethyl) and has been substituted for parathion in mosquito-abatement programs when resistance to the latter has developed (Mulla et al. 1979).

The application of methyl parathion at 5.7 kg/ha (5 lb/acre) to carrington silt loam soil under field conditions, resulted in residues of 0.1 mg/kg within 30 days (Lichtenstein and Schultz 1964). The overall persistence of methyl parathion has been reported to be longer in lake water than soil water. Methyl parthion is of relatively low environmental persistence, its predicted bioconcentration factor is less than 100, and it is degraded more rapidly under high environmental temperatures. The primary metabolic and environmental metabolite of methyl parathion is methyl paraoxon, a potent acetylcholinesterase inhibitor.

Although methyl parathion is widely used on several crops and has relatively high toxicity, the number of documented wildlife-related problems caused by this compound is low. However, wildlife die-off specimens found positive for diethyl parathion often have residues of methyl parathion as well, and these two chemicals are often used together.

Methyl parathion is toxic to bees (Thomson 1982), especially in the microencapsulation formulation. It has been reported to be toxic to fish, shrimp, crabs, and other aquatic arthropods.

Methyl parathion, applied without other pesticides, has been reported in few cases of wildlife problems despite its high toxicity and very high use. It has been recovered from specimens in a number of wildlife die-offs in which other chemicals were also detected in the analyses. Because it is often used in combination with other pesticides, more information on multiple chemical interactions involving this insecticide is needed. The classification of methyl parathion as a restricted-use pesticide may help ensure proper field applications and lower potential exposure to wild birds and mammals. However, high toxicity and use of methyl parathion suggest a potential wildlife risk.

Methyl Trithion

CAS #953-17-3

Toxicity Class: II **Use Class:** VI

Chemical Name: *S*-[[(*p*-Chlorophenyl)thio]methyl] *O*,*O*-dimethyl phosphorodithioate

Action: Insecticide, acaricide

Common and Trade Names: Methyl carbophenothion

Properties: A yellow liquid, miscible with most organic solvents and soluble in water at 1 mg/L.

Field Applications and Formulations: Methyl trithion is an organophosphorus insecticide and acaricide used to control several types of insects and mites.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	A	tech	98	(80–120)	80
	F	A	tech	120	(104–139)	80
European starling	U	U	U	>78		225
Red-winged blackbird	U	U	U	18	(5.6–56)	225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	2,420			146
Rat	M	A	tech	215		(189–245)[a]	80
	F	A	tech	190		(160–226)[a]	80
Japanese quail	U	0.5	85		3,235	(2,575–4,062)	122
Mallard	U	0.3	85		3,000		124
Ring-necked pheasant	U	0.3	85		1,586	(1,333–1,881)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: The production of methyl trithion has been discontinued by the manufacturer (Berg 1982). It is an insecticide and acaricide used to control cotton boll weevils and other insects and mites. Methyl trithion is the methyl homolog of carbophenothion, another organophosphate insecticide. It is much less toxic to mammals and birds than carbophenothion through both oral and dermal routes of exposure. The predicted bioconcentration factor for methyl trithion is also lower than its ethyl homolog. Dietary exposure to birds indicates a relatively low subacute toxicity (Hill et al. 1975). Few data on the environmental fate and persistence are available for methyl trithion, and reports of adverse effects on wildlife resulting from its use are not in the literature.

Mevinphos

CAS #7786-34-7

Toxicity Class: I **Use Class:** V. Restricted

Chemical Name: Methyl 3-hydroxycrotonate, dimethyl phosphate

Common and Trade Names: Duraphos, Gesfid, Menite, Phosdrin, Phosfene

Action: Insecticide, acaricide

Properties: Technical mevinphos is a pale-yellow liquid, highly soluble in water and in most organic solvents.

Field Applications and Formulations: Mevinphos is a systemic and contact organophosphorus insecticide and acaricide with short residual activity. It is used on several field, vegetable, and fruit crops and has a broad spectrum of activity. Primary use is on corn with alfalfa and soybeans also receiving substantial field applications. Mevinphos is formulated in aerosol, dust, emulsifiable concentrates (2–4EC), and as a water-soluble concentrate.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	tech	7–18		138
Rat	M	A	tech	6.1		146
	F	A	tech	3.7		146
European starling	U	U	U	3.9		225
Mallard	F	6–7	100	4.63	(3.57–6.00)	264
Ring-necked pheasant	M	3–4	100	1.37	(0.95–1.98)	264
Sharp-tailed grouse	M	A	100	0.75–1.50		264
	M	A[a]	100	1.37	(0.951–1.98)	131

[a]Some birds may have been in reproductive condition.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			2-year feeding study at 5 ppm in the diet showed no gross health, pathological, or clinical effects	285

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	16–34			285
Rat	M	A	tech	4.7			80
	F	A	tech	4.2			80
Japanese quail	U	0.5	tech		254	(136–475)	122
Mallard	U	0.5	tech		1,991	(1,219–3,240)	124
	F	A	100	11.1		(4.98–24.7)[a]	130
Ring-necked pheasant	U	0.3	tech		246	(210–292)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Of the 158 incidences of wildlife deaths resulting from agricultural chemical use in Scotland from 1973 to 1979, 54 involved mevinphos. All of these incidences were attributed to the misuse of this pesticide (Hamilton et al. 1981).

Persistence and Hazard Evaluation: Mevinphos is a systemic and contact insecticide and acaricide with short residual activity. It is applied to several different crops and it has a broad spectrum of activity. Mevinphos is rapidly metabolized by plants and animals, it is fairly volatile, and its primary route of degradation is through hydrolysis (Vettorazzi 1976; Food and Drug Administration 1982). Residues on lettuce decreased to 0.1 mg/kg 3 days following an application of 1.0 kg/ha (0.88 lb AI/acre; Coffin and McKinly 1964). Residue half-lives for fruits and vegetables range from 2 to 4 days (Hazard Evaluation–EPA 1981; Food and Drug Administration 1982). Half-lives in soils are generally less than 24 h (Burns 1971). Mevinphos has high water solubility suggesting a low predicted bioconcentration potential, and it does not accumulate in tissues (Food and Drug Administration 1982).

Mevinphos is extremely toxic to birds and mammals through both acute oral and dermal exposure. It is one of the most acutely toxic organophosphates marketed; however, there is currently no evidence of any teratogenic, carcinogenic, reproductive, or delayed neurotoxic effects associated with mevinphos exposure (Vettorazzi 1976; Food and Drug Administration 1982). Wildlife mortality caused by mevinphos applications have been associated with the misuse of this chemical in Scotland (Hamilton et al. 1981). No reports of proper field applications resulting in wildlife die-offs are found in the literature. The highly ephemeral nature of mevinphos in the environment may minimize wildlife exposure; however, the acute toxicity of this insecticide to birds and mammals is extremely high and precautions should be taken to avoid exposure.

Mexacarbate

CAS #315-18-4

Toxicity Class: I **Use Class:** VI

Chemical Name: 4-(Dimethylamino)-3,5-xylyl methylcarbamate

Common and Trade Names: Zectran

Action: Insecticide, acaricide

Properties: Soluble in water at 120 mg/L.

Field Applications and Formulations: Mexacarbate is a carbamate insecticide used to control several insect and mite pests on turf, ornamentals, flowers, and forest foliage. It is also effective against snails and slugs. Mexacarbate is formulated as an emulsifiable concentrate (23%), a meal bait (2%), and wettable powder (25%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	15–30		11
Domestic goat	M	A	99+	15–30		131
Mule deer	M/F	5–30	99+	12.5–25.0		131
Rat	M	A	tech	37	(31–45)	80
	F	A	tech	25	(22–28)	80
	U	U	tech	19		11
California quail	F	18	99+	7.14	(2.68–19.0)	131
Canada goose	M/F	U	99+	2.64	(2.0–3.48)[a]	131
Chukar	M/F	4–5	99+	5.24	(4.17–6.61)	131
European starling	U	U	U	32	(18–56)	225
House finch	M	A	99+	4.76[b]	(3.43–6.60)	131
House sparrow	F	A	99+	50.40	(21.9–116)	131
Japanese quail	F	2–3	99+	3.21	(2.45–4.21)	131
Sandhill crane	M/F	U	99+	1.0–4.5		131
Mallard	F	5–7	99+	2.98[b]	(2.50–3.50)[a]	131
Mallard duckling	M/F	0.5	99+	4.2	(3.50–5.00)[a]	131
Mourning dove	M/F	3	99+	2.83[b]	(2.00–4.00)[a]	131
Red-winged blackbird	U	U	U	10	(3.2–32)	225
Ring-necked pheasant	F	A	99+	4.57	(3.42–6.09)	131
Rock dove	M/F	U	99+	6.47	(3.72–11.3)	131
Sharp-tailed grouse	M	A	99+	10.0	(6.50–15.6)	131
Bullfrog	M	U	99+	566	(283–1,131)	131

[a]Range from highest dose producing no mortality to lowest dose producing 100% mortality.
[b]Administered by stomach tube.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	99+	>2,000			264
Rat	M	A	tech	1,500–2,000			146
	F	A	tech	1,500–2,000			146
Japanese quail	U	0.5	93.3		605	(526–697)	122
Mallard	U	0.3	93.3		334	(268–412)	124
Ring-necked pheasant	U	0.3	93.3		846	(724–985)	124

Effects of Field Applications and Field Tests on Wildlife: Mexacarbate applied at 0.2 kg/ha (0.15 lb/acre) to forests did not detrimentally affect radio-equipped blue grouse, and symptoms of carbamate poisoning were not observed. In a series of field experiments, a radio-equipped blue grouse hen lost her brood during two seasons when she was temporarily incapacitated by a sublethal oral exposure to mexacarbate (Mussehl and Schladweiler 1969).

Another forest application of mexacarbate was made at 0.2 kg/ha (0.15 lb/acre) to control spruce budworms. Forest birds and aquatic organisms were censused before and after spraying, and live-caged rock doves and eastern brook trout were exposed to the low-volume aerial application. Adverse effects on aquatic or bird life were not found (Peterson 1967).

Two applications of mexacarbate were applied at 71 g/ha (1 oz/acre) to forests with no observed effects on songbird numbers, nest histories, survival, and behavior of captive birds (Pearce and Rick 1969).

Mexacarbate aerially applied at 0.2 kg/ha (0.15 lb/acre) during a 3-year period in forests to control spruce budworms had no apparent effect on bird and mammal counts and observations (Pillmore et al. 1971).

Persistence and Hazard Evaluation: Mexacarbate production has been discontinued by the manufacturer (Berg 1982). It is an insecticide and acaricide with negligible agricultural use that has been commonly used to control spruce budworms. Applications to forests were generally made using helicopters with low-volume spray. An application of 95% technical mexacarbate at 0.2 kg/ha (0.15 lb/acre) to Douglas fir trees and other plant species resulted in a rapid decrease in residues, and the amounts remaining after 1 week were negligible (Pieper and Miskus 1967).

Mexacarbate is extremely toxic (acute oral) to wild birds and mammals. Its acute dermal and subacute dietary toxicity to the species tested is low to moderate. Little information is available concerning its potential reproductive, mutagenic, carcinogenic, and teratogenic effects. Current field use of mexacarbate in the United States is minimal. Field evaluations following low-volume applications have failed to demonstrate significant adverse effects to wildlife; however, toxicity data suggest that wild birds and mammals exposed to relatively low acute dosages could be killed. Forests applications used in field evaluations have apparently been sufficiently low to not cause effects in wildlife. Chronic toxicological data are not adequate for determining chronic exposure hazards. Lack of current field use suggests that wildlife exposure is likely minimal. The potential hazard of mexacarbate to wildlife appears to be a function of application rates and procedures. Low-volume forest spraying may minimize the risk to wildlife, despite this pesticide's high acute toxicity.

Monocrotophos

CAS #919-44-8

Toxicity Class: I **Use Class:** III. Restricted

Chemical Name: Dimethyl hydrogen phosphate, ester with (*Z*)-3-hydroxy-*N*-methylcrotonamide

Common and Trade Names: Azodrin, Bilobran, Crisodrin, Monocil 40, Monocron, Nuvacron, Pillardrin, Plantdrin, Susvin

Action: Insecticide

Properties: A red-brown solid, soluble in water, alcohol, and acetone. It is hydrolyzed rapidly in pH's greater than 7.0.

Field Applications and Formulations: Monocrotophos is an organophosphorus insecticide with systemic and contact activity. It is used on agricultural crops to control many types of pests. Cotton receives the highest volumes of applications, and other important use crops include sugarcane, peanuts, corn, and tobacco. Monocrotophos is formulated as a soluble concentrate (60%) and in water-miscible solutions (0.383 kg/L [3.2 lb/gal] and 0.599 kg/L [5 lb/gal]).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic goat	F	8–12	>75	20.0–50.0		131
Mule deer	F	8–28	>75	25.0–50.0		131
Rat	M	A	tech	18	(16–19)	146
	F	A	tech	20	(17–23)	146
	U	U	tech	8–23		11
California quail	F	12	>75	0.763	(0.438–1.33)	131

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Canada goose	M/F	U	>75	1.58	(1.10–2.28)	131
Chukar	F	4	>80	6.49	(5.01–8.42)	131
European starling	U	U	U	3.30	(1.9–6.0)	225
Golden eagle	M	I	>75	0.188	(0.094–0.376)	131
Gray partridge	F	A	>75	6.40–12.8		131
House finch	M		>80	8.10–24.3		131
House sparrow	M	A[a]	>75	1.48	(1.07–2.04)	131
Japanese quail	M	2–3	>75	3.71	(2.73–5.03)	131
Mallard	M	4	>80	4.76	(3.43–6.60)	131
Northern bobwhite	M	12–24	>75	0.944	(0.749–1.19)	131
Red-winged blackbird	U	U	U	1.0	(0.56–1.8)	225
Rock dove	M/F	A	>75	2.830	(1.39–5.75)	131
Turkey	M/F	6–18	>75	2.00–3.16		131

[a]Some birds may have been in breeding condition.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			"No effect" chronic oral dietary level of 1.6 ppm in the diet at 2 years	285
Rabbit	U	U	U	336			285
Rat	M	A	tech	126			146
	F	A	tech	112			146
	U	U	U			"No effect" chronic oral dietary level of 1.0 ppm in the diet at 2 years	285
Japanese quail	U	0.5	8.2		2.4	(1.8–2.9)	122
Mallard	U	0.3	8.2		32	(19–547)	124
	U	0.15	8.2		9.6	(7.7–12.0)	124
	M	8–10	>75	30			264
Ring-necked pheasant	U	0.3	8.2		3.1	(2.6–3.7)	124

Effects of Field Applications and Field Tests on Wildlife: The deaths of at least 10,000 robins in Florida farming areas were attributed to the use of monocrotophos that contaminated *Schinus* berries (Stevenson 1972). In an unrelated incident, an unreported number of robins were found dead on the perimeters of potato fields sprayed with monocrotophos. The pesticide company investigating that die-off attributed it to improper application by overspraying the field margins and surrounding hedges where food-stressed robins were feeding (Shell Chemical Company 1972). Another report of an undescribed agricultural incident involving monocrotophos resulted in the death of 20 robins (Hazard Evaluation–EPA 1981).

Studies by the California Department of Fish and Game from 1965 to 1967 concluded that 19 of the 22 incidences investigated involving the use of monocrotophos resulted in wildlife losses in at least 8 different species (California Department of Fish and Game 1967).

Mourning doves and three northern harriers were found dead near an area where chemicals had been applied to kill birds. Monocrotophos was not reported to be one of the chemicals used to control birds on that site, but it was detected in gastrointestinal tracts from the doves and hawks analyzed. Brain cholinesterase activity in the doves was inhibited 85–92% (Coon 1983, personal communication).

Surveys done in areas where cotton fields were treated with 426–568 g AI/ha (6–8 oz AI/acre) to 1.1–1.4 kg AI/ha (1–1.25 lb AI/acre) reported some bird die-offs at the higher rate, including 25 blackbirds and 120 horned larks. Dead birds were found on the edge of cotton fields (Shell Chemical Company 1968). About 400 raptors reportedly died from secondary monocrotophos poisoning by eating poisoned birds and voles (Mendelssohn and Paz 1977).

Several accounts of intentional bird poisoning, especially waterfowl, have been reported. Monocrotophos-soaked rice seed has been illegally broadcast to protect planted rice from bird depredation (White et al. 1983*b*). About 1,100 birds of 12 different species died from eating rice illegally treated with monocrotophos or dicrotophos (Flickinger et al. 1984).

Monocrotophos applied to sugarcane resulted in secondary poisoning of Franklin's gulls that fed upon contaminated cicadas (White and Kolbe 1985).

Persistence and Hazard Evaluation: Monocrotophos is a systemic and contact insecticide with a broad spectrum of activity. Available information indicates that this insecticide has relatively low environmental persistence. Half-lives of monocrotophos applied to cotton leaves were about 7 days (Lindquist and Bull 1967). The oxidative conversion to its N-methylol environmental metabolite is also minor (Lindquist and Bull 1967; Menzie 1974). A 1.1 kg/ha (1 lb/acre) application to sweet corn resulted in corn residues decreasing from 0.1 mg/kg at 1 h after application to one-tenth of that amount 4 days later (Young and Bowman 1967).

Monocrotophos is extremely toxic to birds and mammals. Acute oral LD50's of less than 1 mg/kg have been reported for some bird species, and its acute dermal toxicity is also high. Monocrotophos fed to young Japanese quail, mallards, and ring-necked pheasants over a 5-day period, followed by 3 days of untreated feed, resulted in LC50 values between 3.1 and 32 mg/kg, which were the lowest LC50 values of the 131 compounds tested (Hill et al. 1975). The effectiveness of monocrotophos to kill birds is attested to by its illegal use as a bird poison. There are numerous incidences of both unintentional and intentional bird poisonings using monocrotophos, and most reports of bird kills are related to intentional poisoning or improper application. A review of pesticide effects on rangelands cited one study in which the application of monocrotophos at 497 g/ha (7.0 oz/acre) to wheat in an early growth stage resulted in heavy bird and mammal mortality (McEwen 1982).

It is evident that if exposed to monocrotophos through feed or water, wildlife can be killed, and that large numbers of birds have been killed as a result of intentional poisonings. Careful evaluation of wildlife exposure should be made prior to the use of this insecticide.

Naled

CAS #300-76-5

Toxicity Class: III **Use Class:** V

Chemical Name: 1,2-Dibromo-2,2-dichloroethyl dimethyl phosphate

Common and Trade Names: Bromchlophos, Bromex, Dibrom, Hibrom

Action: Insecticide, acaricide

Properties: The technical product is a yellow liquid, soluble in aromatic and chlorinated hydrocarbons and alcohols but nearly insoluble in water. It is stable under anhydrous conditions, hydrolyzed by water, and degraded by sunlight.

Field Applications and Formulations: Naled is a nonsystemic organophosphorus insecticide and acaricide with contact and stomach-poison activity. It is used to control many types of pests, and important agricultural crops receiving substantial applications include tomatoes, grapes, and alfalfa. It is applied to livestock and agricultural premises, although a primary field use is in public health mosquito- and insect-control programs. Formulations include dust (4%), emulsifiable concentrates (4, 8, 12, and 14EC), and spray concentrates.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mule deer	M/F	U	93	200		131, 264
Rat	M	A	tech	250	(219–285)	146
Canada goose	M/F	U	93	36.9	(27.2–50.0)	264
	M/F	U	93	49.9	(31.7–78.6)	131
Mallard	M	U	93	52.2	(37.8–72.3)	131, 264
Ring-necked pheasant	M	3–4	92	120	(30.0–480)	131
Sharp-tailed grouse	M	A	93	64.9	(37.3–113)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	1,100			11
Rat	M	A	tech	800		(559–1,144)[a]	80
	U	U	99			No "toxic effects" observed during an 84-day feeding trial at 100 ppm (tech) in the diet	285
	U	U	91			No "toxic effects" observed during a 2-year feeding trial at 200 ppm in the diet	285
Japanese quail	U	0.5	tech		1,328	(1,130–1,561)	122
Mallard	U	0.3	tech		2,724	(1,068–15,089)	124
Northern bobwhite	U	0.3	tech		2,117	(1,502–2,890)	124
Ring-necked pheasant	U	0.3	tech		2,538	(2,221–2,896)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Observations made following aerial spraying of naled at 0.4 kg/ha (0.4 lb/acre) did not indicate that spraying was detrimental to blue grouse (Mussehl and Schladweiler 1969). Observations in forests sprayed with naled at 0.4 kg/ha (0.4 lb/acre) and sampled in 8-ha (20-acre) plots to determine bird and mammal abundance before and after treatment showed no apparent harmful effects (Pillmore et al. 1971). Applications made in Florida to seashore, palmetto, mangroves, citrus areas, and residental areas at a rate of 0.1 kg actual/acre (0.1 lb/acre), resulted in no noticeable "ill effects" on wildlife (Whipp 1960).

Persistence and Hazard Evaluation: Naled is a contact and stomach-poison insecticide and acaricide with some fumigant activity. It is produced by the bromination of another organophosphate insecticide, DDVP (Eto 1974). Naled is more stable than DDVP, although it is readily hydrolyzed in water and half-lives are about 2 days (Eto 1974). Soil degradation is also rapid, and it is readily transformed into DDVP, which may be the actual insecticidal agent (Eto 1974; Food and Drug Administration 1982). Although naled is practically insoluble in water, the few data available suggest a low bioaccumulation potential (Food and Drug Administration 1982). DDVP also has a low predicted bioconcentration factor.

Naled has moderate acute toxicity to mammals tested but appears more toxic to birds. It has moderate to low dermal toxicity and LC50's for birds indicate low subacute dietary toxicity. Naled may be toxic to bees (Thomson 1982). There are no reports indicating that field applications of naled have resulted in negative effects on wildlife. Its degradation product, DDVP, is more acutely toxic than naled and should be considered present when naled is applied in the field. Delayed neurotoxic effects in hens or teratogenic effects in other species have not been found in studies of this insecticide (Food and Drug Administration 1982).

Naled is commonly used in areas that provide wildlife habitat. There are no reported incidences of wildlife problems related to naled use; however, wildlife mortalities in areas where naled is used (e.g., wetlands) may be more difficult to detect than in agricultural areas. Naled does have low environmental persistence, which may minimize prolonged exposure to wildlife.

Oxamyl

CAS #23135-22-0

Toxicity Class: I **Use Class:** V

Chemical Name: Methyl *N′,N′*-dimethyl-*N*-[(methylcarbamoyl)oxy]-1-thiooxamimidate

Common and Trade Names: Vydate

Action: Insecticide, nematicide, acaricide

Properties: A white crystalline solid, soluble in water at 280,000 mg/L. Oxamyl decomposes rapidly in water and soil (Worthing 1979).

Field Applications and Formulations: Oxamyl is a systemic and contact carbamate insecticide also effective against mites and nematodes. Foliar applications control a broad range of insects and mites, and oxamyl is also incorporated into the soil as a preplant treatment for nematodes. Foliar applications are translocated to the roots in certain plants and have nematicidal activity (Worthing 1979). The major crops are potatoes and tomatoes. Oxamyl is formulated as an emulsifiable concentrate (2EC) and in granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	5.4		11
	M	U	24	37		11
Japanese quail	U	U	U	4.18		285
	U	0.25	92	4.3	(2.7–6.7)	245
Mallard	U	0.5	24	2.6	(1.9–3.4)	245
Northern bobwhite	U	0.5	24	9.4	(7.0–12.6)	245

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	M	U	24	710			285

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Japanese quail	U	U	92			Quail fed up to 33 mg/kg body weight showed no compound-related clinical effects	245
Mallard	U	0.5	24		369[a]	(250–544)	245
Northern bobwhite	U	0.5	24		54[a]	(41–91)	245

[a]8-day dietary LC50.

Effects of Field Applications and Field Tests on Wildlife: Nine-week-old northern bobwhites and 10-week-old New Zealand rabbits were sprayed in pens using ground equipment at 3.4 kg/ha (3 lb/acre; 24% AI). This application rate was three to six times the normal rate, and three treatments were made at 3-week intervals. Mortalities, clinical signs of toxicity, or gross pathologic abnormalities did not result. It was concluded that oxamyl posed little hazard to birds under field conditions and a lower potential hazard than expected from acute studies alone (Smith 1982).

Persistence and Hazard Evaluation: Oxamyl is an insecticide and nematicide also effective against mites. It has contact and moderate residual activity. It is applied to both soil and foliage and has an overall low environmental persistence. Oxamyl is mobile in the soil and under field conditions, half-lives are about 1 week (Harvey and Han 1978). Other studies have reported half-lives in soils from 6 to 15 days (Menzie 1974).

Oxamyl is extremely toxic to laboratory rats and to wild birds given an acute oral exposure. Subacute toxicity is moderate to high for birds, and it is reported to be toxic to bees, fish, and wildlife (Thomson 1982). Despite its high acute oral toxicity, one simulated field study exposed quail and rabbits up to six times the normal application rate and did not cause mortality or overt symptoms of poisoning (Smith 1982). This field test suggested a relatively low potential for field applications to cause wildlife mortality. Moreover, oxamyl's short environmental persistence likely minimizes exposure to wildlife. No reports of oxamyl causing adverse effects in wild birds and mammals are found in the literature. Because of its high toxicity and moderate field use, further field evaluations with emphasis on wildlife effects would be useful.

Oxydemeton-methyl

CAS #301-12-2

Toxicity Class: II **Use Class:** V

Chemical Name: *S*-[2-(Ethylsulfinyl)ethyl] *O,O*-dimethyl phosphorothioate

Common and Trade Names: Demeton-S-methyl sulfoxid, Metasystemox, Metasystox-R, Metilmercapto fosoksid

Action: Insecticide, acaricide

Properties: A clear, amber liquid soluble in water and most organic solvents but nearly insoluble in petroleum ether. It is relatively stable under alkaline conditions (Eto 1974).

Field Applications and Formulations: Oxydemeton-methyl is a systemic organophosphorus insecticide and acaricide with contact activity. It used to control sap-feeding insects and mites and aphid vectors of viral diseases. Major agricultural use crops are corn and alfalfa, with cotton, potatoes, ornamentals, and several other crops receiving minor applications. Formulations include an emulsifiable concentrate (2EC) and a soluble concentrate (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	M	U	U	120		57
Mouse	U	U	U	30		146
Rat	M	A	tech	47	(40–55)	80
	F	A	tech	52	(42–65)	80
	F	U	50	48		36
	F	U	0.479 kg/L (4 lb/gal)	125		36
California quail	M	6	50	47.6	(34.3–66.0)	131
Chukar	M/F	3–4	50	113	(81.7–157)	264
	M/F	3–11	50	120	(81.4–177)	131
House sparrow	M	U	50	70.8	(43.4–116)	131, 264
Japanese quail	F	2	50	84.1	(60.6–117)	264
Mallard	M	4	50	53.9	(38.9–74.8)	131, 264
Ring-necked pheasant	M/F	3–4	50	42.4	(30.6–58.8)	131, 264
Rock dove	M/F	U	50	14.9	(10.7–20.6)	264
	M/F	U	50	14.0	(8.84–22.3)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	50	225			36
	U	U	0.240 kg/L (2 lb/gal)	250–400			36
Rat	M	A	tech	173		(145–206)[a]	80
	F	A	tech	158		(148–169)[a]	80
	M/F	U	U			90-day feeding study at 0–125 ppm showed ChE inhibition at levels above 25 ppm; at 125 ppm growth rates were reduced and mortality increased in males	75
Japanese quail	U	0.5	50		1,256	(961–1,642)	122
Mallard	U	0.3	50		>5,000	No mortality at 1,000, 38% at 5,000	124
Northern bobwhite	U	0.5	50		434	(304–600)	124
Ring-necked pheasant	U	0.3	50		1,497	(1,326–1,690)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Oxydemeton-methyl is a contact systemic insecticide effective against sucking insects and mites. Oxidative degradation produces oxydemeton-methyl sulfone, which also has anticholinesterase activity. Hydrolysis products are probably not cholinesterase inhibitors (Food and Drug Administration 1982). Foliar residues on most crops receiving oxydemeton-methyl applications have half-lives of about 7 days (Food and Drug Administration 1982). Half-lives in soils are about 6 days under field conditions, and available data suggest a low potential for bioconcentration (Food and Drug Administratiŏn 1982).

Oxydemeton-methyl is of moderate to high acute toxicity in birds and mammals. Acute oral LD50's range as low as 14.9 mg/kg in rock doves (Tucker and Crabtree 1970); however, 5-day dietary LC50's are high and suggest moderate to low toxicity given subacute exposure. Both the parent compound and its oxidative sulfone metabolite have anticholinesterase activity. Although used on corn, alfalfa, and other crops where wildlife may be present, incidences relating wildlife die-offs to the use of oxydemeton-methyl are not found in the published literature.

Parathion

CAS #56-38-2

Toxicity Class: I **Use Class:** I.[1] Restricted

Chemical Name: *O,O*-Diethyl *O*-(*p*-nitrophenyl) phosphorothioate

Common and Trade Names: Alkron, Alleron, Aphamite, Bladan, Corothion, Diethyl Parathion, Drexel Parathion 8E, Ekatox, Ethyl Parathion, Etilon, Folidol, Fosferno, Niran, Orthophos, Panthion, Paramar, Paraphos, Parathene, Parawet, Phoskil, Rhodiatox, SNP, Soprathion, Stathion, Thiophos

Action: Insecticide

Properties: Technical parathion is a pale-yellow liquid that is soluble in most aromatic solvents and slightly soluble in water at 24 mg/L. It is hydrolyzed under alkaline conditions.

Field Applications and Formulations: Parathion is a broad-spectrum, nonsystemic organophosphorus insecticide used on a wide variety of crops and formerly used to some degree for mosquito control. It is formulated as aerosol (10%), dusts (1 and 2%), emulsifiable concentrates (2, 4, 6, and 8EC), granules (10%), and wettable powders (15 and 25%). When formulated with methyl parathion, it is marketed as Sixty-three special EC.

[1]Parathion and Methyl parathion were combined in field-use surveys.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic goat	M	12–72	98.76	28.0–56.0		131
Dog	U	U	U	3		146
Mouse	U	U	U	6–25		146
Mule deer	M	9–10	99.5	22.0–44.0		131
Rabbit	U	U	U	10		146
Rat	M	U	U	13		11
	F	U	U	3.6		11
California quail	M	5–6	99.5	16.9	(12.2–23.5)	131
Chukar	M/F	3–24	98.76	24.0	(16.8–34.2)	131
European starling	U	U	U	5.6	(0.76–40)	225
Fulvous whistling-duck	M/F	U	98.76	0.125–0.250		131
Gray partridge	M	3–10	98.76	16.0	(4.0–64.0)	131
House sparrow	M	U[a]	98.76	3.36	(2.43–4.66)	131
Japanese quail	F	2[a]	98.76	5.95	(3.38–10.5)	131

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mallard	M	12[a]	99.5	2.34	(1.88–2.92)	131
	F	12[a]	99.5	1.44	(1.13–1.83)	131
	F	15	99.5	1.44	(1.16–1.80)	131
	M	3–4	98.76	2.40	(1.67–4.01)	131
	F	2–3	98.76	1.90	(1.37–2.64)	131
Northern bobwhite	M/F	A	tech	6	(4–9)	121
	M/F	A	10G	13	(8–21)	121
Red-winged blackbird	U	U	U	2.4		225
Ring-necked pheasant	M	2–3	98.76	12.4	(10.1–15.2)[b]	131
	F	12[a]	99.5	>24.0		131
Rock dove	M/F	U	98.76	2.52	(1.82–3.50)	131
Sharp-tailed grouse	F	12–36	98.76/98.6	5.66	(3.46–9.24)	131

[a]Some birds in breeding condition.
[b]Range of highest dosage producing no mortality to lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			"No effect" chronic oral dietary level of 1 ppm in the diet at 90 days	146
Rabbit	U	U	U	40–870			146
Rat	U	U	U	4–200		"No effect" chronic oral dietary level of 1–50 ppm in the diet at 90 days	146
	M	U	U	21			285
	F	U	U	6.8			285
Japanese quail	U	0.5	99.5		238	(152–373)	122
	U	0.5	79		238	(181–312)	122
Mallard	M	A	99.5	28			225
	U	0.15	99.5		76	(61–93)	124
	U	0.30	99.5		275	(183–373)	124
Northern bobwhite	U	0.5	99.5		194	(150–245)	124
Ring-necked pheasant	U	0.3	99.5		336	(296–380)	124

Effects of Field Applications and Field Tests on Wildlife: Hundreds of birds, including red-winged blackbirds and common grackles, were reportedly killed in a corn field that had loose corn treated with parathion. This was apparently an incident of intentional poisoning (Coon 1983, personal communication). Mourning doves, rock doves, and starlings composed the hundreds of birds killed in an area where a farmer was suspected of poisoning depredating birds. Crop contents of these birds had corn with high residues of parathion and some methyl parathion (Stone 1979). Mass mortality of many bird species in Europe was attributed to seed poisoned with parathion by farmers (Mörzer-Bruijns 1963). Survey results indicated that granular applications of parathion at rates of

2.3–3.4 kg/ha (2–3 lbs/acre) resulted in 0.5–5.2 dead birds found per treated hectare (Mills 1973). Several other reports of intentional bird poisonings using parathion are found in the literature (Stone et al. 1979; Hazard Evaluation–EPA 1981).

An accidental aerial application of 11.3 g parathion/L of water per ha (0.75 lb parathion/20 gal of water per acre) on 5 ha (12.5 acres) on a National Wildlife Refuge by a private applicator resulted in death of an unreported number of geese (Coon 1983, personal communication; Hazard Evaluation–EPA 1981). In another incident, an estimated 1,200 geese were killed and laboratory analyses confirmed ChE inhibition (83%) and residues of parathion and methyl parathion in the gastrointestinal tracts of specimens (Coon 1983, personal communication). A total of 1,600 waterfowl, mainly Canada geese, were killed in an area where a wheat field had been sprayed with a 2:1 mixture of parathion and methyl parathion at a rate of 0.8 kg/ha (0.75 lb/acre; White et al. 1982). Another reported parathion treatment of wheat resulted in a wild goose die-off, suggesting that even when applied to wheat at recommended rates, parathion is extremely toxic to geese (White et al. 1982).

More than 216 adult and immature laughing gulls were found dead near cotton fields sprayed with 1.1 kg/ha (1 lb/acre) parathion. Cholinesterase inhibition and parathion residues in digestive tracts indicated parathion poisoning to be the cause of death for most birds. It was concluded that adults died from ingestion of poisoned insects and that gull chicks died either from contaminated food (insects) regurgitated to them or from starvation due to the death of their parents (White et al. 1979). A single oral dose of 6 mg parathion/kg body weight reduced nest attentiveness in laughing gulls (White et al. 1983*a*).

An experimental aerial application of parathion at 0.9 kg/ha (0.8 lb/acre) to wild and penned ring-necked pheasants did not produce direct mortality; however, some birds showed signs of organophosphorus poisoning and later recovered (Messick et al. 1974). Another study involved aerially spraying large enclosures containing 9-week-old pheasants at a rate of 568 g/ha (8 oz/acre; Wolfe et al. 1971). No mortality was observed; however, brain and plasma ChE were depressed up to 46% (Wolfe et al. 1971). The application of parathion at 0.6 and 3.4 kg/ha (0.5 and 3 lb/acre) did not produce mortality at the lower rate, and 4 of 42 penned pheasants were killed at the higher rate (Zorb 1967*b*). Seven months later, it was determined that neither of these application rates had affected pheasant reproductive parameters (Zorb 1967*b*).

A 1.1 kg/ha (1.0 lb/acre) aerial application of parathion to a duck pond was reported to have had no obvious adverse effects on pinioned adult mallards (Mulla et al. 1966). In a laboratory experiment, tadpoles were exposed to parathion in a continuous-flow dosing apparatus at 5 and 1 mg/L for 96 h and then fed to mallard ducklings. All ducklings died after consuming a single meal of tadpoles, and brain cholinesterase was severely depressed (Hall and Kolbe 1980).

Adult cricket frogs held for 96 h in water containing initial concentrations of 0, 0.1, 1.0, and 10 ppm parathion experienced dose-related mortality and accumulated parathion. One of four American kestrels fed frogs from the 10 ppm group died after consuming five frogs (Fleming et al. 1982).

Persistence and Hazard Evaluation: Parathion is a broad-spectrum, nonsystemic insecticide and was the first commercially successful organophosphate insecticide marketed. It is moderately persistent in the environment and loss of biological activity usually occurs within 2–4 weeks. Applied to grapevines at 2.3 kg/ha (2 lb/acre emulsifiable concentrate), residues in bark stabilized at 25 mg/kg for at least 70 days (Eto 1974). Applications to tobacco and lettuce, at rates between 0.6 and 1.7 kg/ha (0.5 and 1.5 lb/acre), generally resulted in residues less than 0.1 mg/kg in 2 weeks (Coffin 1966; Keil et al. 1972; Keil et al. 1973). Spinach residues were 0.3 and 0.5 mg/kg at 14 days after 0.6 kg/ha (0.5 lb/acre) and 1.1 kg/ha (1 lb/acre) applications, respectively (Archer 1974). Higher application rates are used for soil treatment, and persistence in soil is longer. Applied to water at 20°C, it persisted for 690 days (Pimental 1971). Using a continuous-flow dosing system, parathion was determined to bioconcentrate in tadpoles an average of 64 times (Hall and Kolbe 1980). It is metabolically oxidized to paraoxon, a potent cholinesterase inhibitor that is less stable.

Parathion is extremely toxic to birds and mammals given an acute oral exposure. It is readily absorbed through the skin and low acute dermal LD50's have been determined for both laboratory and wild species. Although parathion has been used to poison "pest" bird species, it has also been implicated as the causative agent more often in unintentional wildlife die-offs than any other organophosphate. Ingestion of sublethal amounts of parathion has been found to impair reproduction and lower tolerance to cold temperatures in northern bobwhites (Rattner et al. 1982).

Parathion exposure has been documented to cause wildlife die-offs and produce adverse sublethal effects that could impact wildlife populations. The use of this highly toxic chemical instead of less toxic insecticides should be critically evaluated before application.

Phorate

CAS #298-02-2

Toxicity Class: I

Use Class: III. Restricted

Chemical Name: *O,O*-Diethyl *S*-[(ethylthio)methyl] phosphorodithioate

Common and Trade Names: Granutox, Phorate 15-G, Rampart, Thimet, Timet, Vegfru Foratox

Action: Insecticide, acaricide

Properties: A clear liquid miscible in alcohols, ethers, esters, xylene, and vegetable oils. It is stable for 2 years at room temperature and is subject to hydrolysis under highly acidic (pH <2) or alkaline (pH >9) conditions. Its water solubility is 50 mg/L (Worthing 1979).

Field Applications and Formulations: Phorate is an organophosphorus soil insecticide and acaricide with contact, fumigant, and systemic activity. It is used on several different types of crops but primarily on corn. Other major crops include cotton, potatoes, and soybeans. It is also used as a seed treatment for cotton, corn, and soybeans. Field application rates range from 0.6 to 3.4 kg actual/ha (0.5 to 3 lb/acre). Phorate is available as emulsifiable concentrates (6 and 8EC) and in granules (10, 15, and 20%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	90	3.7		104
	F	U	90	1.6		104
Chukar	F	I	98.8	12.8	(3.2–51.2)	264
European starling	U	U	U	7.5		225
Mallard	F	3–4	98.8	0.616	(0.367–1.03)	131
	F	12	88	2.55	(2.02–3.21)	131
Northern bobwhite	M/F	A	tech	7	(4–11)	121
	M/F	A	15G	21	(14–31)	121
Red-winged blackbird	U	U	U	1.0	(0.56–1.8)	225
Ring-necked pheasant	F	3–4	98.8	7.12	(4.94–10.3)	264
Bullfrog	F	U	98.8	85.2	(59.3–122)	264

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Guinea pig	U	U	tech	20–30			285
Rat	U	U	tech	2.5–6.2			285
	U	U	U			90-day feeding trial at 6 ppm in the diet with "no effect" except ChE inhibition	285

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Japanese quail	U	0.5	90		575	(483–699)	122
Mallard	U	0.3	90		248	(198–306)	124
	F	A	88	203		(149–276)[a]	130
Northern bobwhite	U	0.5	90		373	(326–431)	124
Ring-necked pheasant	U	0.3	90		441	(381–510)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Phorate was sprayed on forage in sheep enclosures at 0.6 and 1.1 kg/ha (0.5 and 1.0 lb/acre). Sheep ate only unsprayed grass unless forced by starvation to eat treated forage. Ingestion of sprayed grass treated at the 1.1 kg/ha (1 lb/acre) level resulted in the death of one of two sheep, and ChE activity was severely inhibited in sheep ingesting grass treated at the 0.6 kg/ha (0.5 lb/acre) level (McCarty et al. 1969).

Many ring-billed gulls were found dead in a field that had been sprayed with granular phorate 2 days earlier. Brain ChE activity was inhibited an average of 92% for the 10 birds collected, and the ingesta of six birds contained phorate (Hill and Fleming 1982).

A total of 346 waterfowl and 14 raptors were found dead in two separate areas about 160 km (100 mi) apart. In each area, bags of phorate (Thimet 15G) were found, and each site had received heavy rains. Of the 14 specimens analyzed, all but one goose had inhibited brain ChE activity (73–91%) or residues of phorate in the digestive tract (Coon 1983, personal communication).

Persistence and Hazard Evaluation: Phorate is a contact and systemic insecticide that is readily taken up by plants. Plants absorb greater amounts of phorate from sandy soils than from heavier soils (Getzin and Chapman 1960). Its relatively low predicted bioconcentration factor and moderate to high soil absorption coefficient indicate that it is likely not highly persistent, and heavy precipitation may be required to translocate the chemical to water by soil particle runoff (Kenaga 1980). The major oxidative products of phorate in soil are phorate sulfoxide and sulfone (Walter-Echols and Lichtenstein 1977). These products, along with the parent compound, may persist beyond 16 weeks in silt loam soil (Getzin and Shanks 1970) and are subsequently degraded primarily by hydrolysis (Chapman et al. 1982). Phorate may retain its insecticidal activity up to 4–12 weeks (Thomson 1982), and hydrolysis is enhanced under highly acidic (pH <2) and alkaline (pH >9) conditions (Worthing 1979). Total residues of phorate and its metabolites, originally applied at 0.6–2.3 kg/ha (0.5–2.0 lb/acre), declined below 1.0 mg/kg after 14 days in corn and after 21 days in bermuda grass (Leuck and Bowman 1970). Under flooded conditions phorate is more persistent (Walter-Echols and Lichtenstein 1978). Reduction of phorate sulfoxide to the more toxic parent compound by microorganisms is enhanced in lake mud (Leuck and Bowman 1970).

It appears that under certain conditions phorate and its anticholinesterase oxidative products may persist from 1 to 4 months. Reduction of the oxidative products to the more toxic parent compound may occur under flooded conditions. Highly acidic or alkaline conditions facilitate the hydrolysis of phorate and its metabolites to nontoxic products.

Phorate is extremely toxic to birds and mammals given either oral or dermal exposure. It is a potent, irreversible cholinesterase inhibitor (McCarty et al. 1969; Hill and Fleming 1982), and its oxidative products, phosphorodithiolate sulfoxide and sulfone, are also powerful cholinesterase inhibitors (Bowman and Casida 1958). Phorate is commonly applied to the soil at a rate of 0.6–3.4 kg/ha (0.5–3 lb/acre) in a granular formulation. Livestock should not be grazed in treated fields, and wildlife exposed to phorate are likely to be poisoned. Phorate is also toxic to bees. Because of its systemic activity, it is readily translocated to plants, facilitating possible wildlife exposure through foraging. Exposure levels as low as 0.09 mg technical/kg have produced anti-ChE symptoms in mallards (Tucker and Crabtree 1970).

In areas subject to flooding and runoff, and where wildlife are present, the use of this pesticide should be carefully evaluated.

Phosalone

CAS #2310-17-0

Toxicity Class: II **Use Class:** III

Chemical Name: *O,O*-Diethyl hydrogen phosphorodithioate, *S*-ester with 6-chloro-3-(mercaptomethyl)-2-benzoxazolinone

Common and Trade Names: Azofene, Benzphos, Rubitox, Zolone

Action: Insecticide, acaricide

Properties: Colorless crystals soluble in water at 10 mg/kg (Worthing 1979) and soluble in most aromatic solvents. Phosalone is stable under normal storage conditions and compatible with most other pesticides (Worthing 1979).

Field Applications and Formulations: Phosalone is an organophosphorus insecticide applied preharvest to fruit- and nut-bearing trees to control many types of insects and mites. The major crop is pecans; other minor use crops include apples and walnuts. Phosalone is formulated as dust (4%), emulsifiable concentrate (3EC), and wettable powder (25%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	U	U	U	82–150		46
Mouse	U	U	U	180–205		46
Rat	M	U	U	120		46
	F	U	U	135–170		46
Ring-necked pheasant	U	U	U	290		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			290 ppm in the diet with "no effect" at 2 years	285
Rabbit	U	U	U	>1,000			285
Rat	F	U	U	390			46
	U	U	U	1,500			285
	U	U	U			250 ppm in the diet with "no effect" at more than 1 year	46
Japanese quail	U	0.5	25	4,737		(3,530–6,536)	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Phosalone is a nonsystemic, broad-spectrum insecticide and acaricide used primarily on fruit- and nut-bearing deciduous trees. It is used to control mites, aphids, and several other insect pests.

Although it is nonsystemic, phosalone has been found to penetrate plant tissue, and as much as 40% of initial residues may remain up to 15 days after application (Colinese and Terry 1968). Soil residues from an application of 6.0 kg AI/ha (5.3 lb AI/acre), about 3.5 times the normal application rate, were 3 mg/kg and 0.5 mg/kg at 14 and 28 days after application, respectively (Colinese and Terry 1968). Simulated heavy rains did not cause migration of phosalone in soils (Colinese and Terry 1968). Half-lives of phosalone have been determined to be about 3–7 days (Ambrosi et al. 1977). Bioaccumulation ratios (tissue concentration/water concentration) were 48, 170, and 240 for snails, algae, and fish exposed to phosalone in a model aquatic ecosystem (Ambrosi et al. 1978), respectively.

Phosalone is moderately toxic to laboratory animals; however, its toxicity to most wildlife species has not been evaluated. It is reported to be rapidly absorbed, metabolized, and excreted by rodents and to decompose readily in animals and soils (Vettorazzi 1976). It is not neurotoxic to chickens and is not teratogenic in the chick or the rat (Vettorazzi 1976). Phosalone is commonly used in the southeastern United States on orchard crops, especially pecans. It is relatively nonpersistent. Its acute toxicity to rodents is potentiated by several other organophosphates, particularly disulfoton (Vettorazzi 1976). Wildlife die-offs, or other adverse effects due to phosalone applications, are not reported in the current literature.

Phosmet

CAS #732-11-6

Toxicity Class: II **Use Class:** III

Chemical Name: *O,O*-Dimethyl hydrogen phosphorodithioate, *S*-ester with *N*-(mercaptomethyl)phthalimide

Common and Trade Names: Appa, Imidan, Kemolate, Phthalophos, PMC, Prolate

Action: Insecticide, acaricide

Properties: An off-white crystalline solid, soluble in water at 25 mg/L and compatible with most other nonalkaline pesticides.

Field Applications and Formulations: Phosmet is a nonsystemic organophosphorus insecticide and acaricide registered for use on several crops to control a broad range of insects and mites. The major agricultural use is on apples, and other important crops include peaches, alfalfa, cotton, almonds, and citrus. It is also used in some forestry pest control programs and as an insecticidal treatment on livestock. Phosmet is formulated as an emulsifiable concentrate and a wettable powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	A	tech	113	(101–127)	80
	F	A	tech	160	(143–179)	80
European starling	U	U	U	>100		225
Mallard	M	3–4	97.2	1,830	(1,270–2,630)	131
Red-winged blackbird	U	U	U	18	(10–32)	225
Ring-necked pheasant	M	3	97.2	>250		131
	F	3–4	97.2	237	(171–329)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog/Rat	U	U	U			"No effect" chronic dietary level of 40 ppm in the diet at 2 years	285
Rabbit	U	U	tech	3,160			250
	U	U	50	>4,000			250
Japanese quail	U	0.5	98.3		2,072	(1,721–2,426)	122
	U	0.5	12.5 (WP)		2,041	(1,492–2,792)	122
Mallard	U	0.3	98.5		>5,000	38% mortality at 5,000 ppm	124
Northern bobwhite	U	0.5	98.5		501	(340–781)	124
Ring-necked pheasant	U	0.3	98.5		3,146	(2,624–3,804)	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Phosmet is a contact insecticide and acaricide used to control a broad spectrum of pests on agricultural crops, in forests, and on livestock. It is reported to have minimal effects on beneficial insect parasites and predators and has, therefore, been recommended for use in integrated pest management programs (Stauffer Chemical Company 1973). Phosmet has relatively low environmental persistence and degrades to nontoxic products through hydrolysis and microbial degradation (Stauffer Chemical Company 1973). Half-lives for phosmet in sandy loam and loamy soils ranged from 3 to 19 days (Menn et al. 1965), and persistence is greater in dry soils (Stauffer Chemical Company 1973). Applications of phosmet (3EC) to corn, bermuda grass, and soybeans at rates up to 1.14 kg/ha (16 oz/acre) resulted in residues of 0.63, 0.76, and 0.57 mg/kg after 15 days, respectively (Leuck and Bowman 1968*a*). The oxygen analog, imidoxon, was not detected after 7 days in corn or soybeans, or after 15 days in bermuda grass (Leuck and Bowman 1968*a*).

Phosmet is moderately toxic to most of the species tested; however, toxicity data for wildlife indicate marked variability among species. Phosmet has also been reported to be toxic to bees and fish (Thomson 1982).

The low persistence, low predicted bioconcentration potential, and the types of crops that phosmet is applied to may minimize exposure to wildlife. However, high variability in toxicological data available suggest that more information on the acute and subacute toxicity of this chemical be obtained to assess its potential risk.

Phosphamidon

CAS #297-99-4[1]

Toxicity Class: I

Use Class: V. Restricted

Chemical Name: Dimethyl hydrogen phosphate, ester with 2-chloro-*N*,*N*-diethyl-2-hydroxycrotonamide

Common and Trade Names: Dimecron, Dixon, Famfos

Action: Insecticide, acaricide

Properties: A pale-yellow liquid, soluble in organic solvents and water and relatively stable in nonalkaline solutions.

[1]CAS registry number for *trans*-phosphamidon.

Field Applications and Formulations: Phosphamidon is a systemic organophosphorus insecticide and acaricide with contact and stomach poison activity. Apples receive the major agricultural applications of phosphamidon, and other relatively high-use crops include walnuts and tomatoes. It is also applied as a forest insecticide to control gypsy moths and spruce budworms. It is formulated in emulsifiable concentrates (8, 20, 50, and 100%) and as a wettable powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	M/F	U	tech	50		222
Mouse	M	U	tech	11.2		222
	F	U	tech	9.0		222
Mule deer	M/F	24–36	85	44.0–88.0[a]		131
Rat	M	U	tech	28.2–30.0		222
	M	A	tech	24	(18–31)	80
	F	A	tech	24	(18–31)	80
	M	U	80	11.0	(9.39–12.8)	131
	M/F	U	20	15		222
	M/F	U	50	30	(24.2–39.7)	222
	M/F	U	100	12	(9.6–14.9)	222
Chukar	M/F	3–5	80	9.7	(8.3–11.3)	264
Japanese quail	F	A	85	3.60[a]	(1.80–7.20)	131
Mallard	F	3	80	3.05	(2.33–4.00)	264
	F	3	80	3.81[a]	(2.91–5.00)	131
Mourning dove	M/F	U	80	2.0–4.0		264
Rock dove	M/F	U	80	2.0–3.0		264
	M/F	U	80	2.11–3.66		131
Ring-necked pheasant	F	4	85	4.24[a]	(3.37–5.34)	131
Sharp-tailed grouse	M	12–24[b]	85	1.50–3.00		131
White-winged dove	M/F	A	80	2.34		264
	M/F	A	80	2.93[a]	(2.44–3.66)[c]	131

[a]Administered by stomach tube.
[b]Some birds may have been in breeding condition.
[c]Range from highest dose producing no mortality to lowest dose producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	M/F	U	U			In a 2-year feeding study at 0.1, 2.5, and 5.0 mg/kg per day, all died at the 5 mg/kg level with some ChE inhibition at 2.5 mg/kg and no observed effects at 0.1 mg/kg	222
Rat	M/F	U	tech	374		(247–564)[a]	222
	M/F	U	20	125–530			222
	M/F	U	50	250		(127–485)[a]	222

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M/F	U	100	250		(164–380)[a]	222
	M	A	tech	143		(121–169)[a]	80
	F	A	tech	107		(78–147)[a]	80
Japanese quail	U	0.5	78		90	(73–111)	122
Mallard	U	0.3	78		712	(558–887)	124
	F	13–15	85	26.0		(0.25–129)[a]	130
	M/F	5–43 days	U			Different age ducklings were exposed to a 13-day dietary treatment at 0, 0.5, and 5.0 ppm during a 10-week growth period; primary feather development, body weight, and wing length were affected, at different intervals	115
Northern bobwhite	U	0.30	78		24	(10–37)	124
Ring-necked pheasant	U	0.25	78		77	(68–87)	124

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: Phosphamidon applied to forested land at 1.1 kg/ha (1 lb/acre) for spruce budworm control killed some blue grouse and other birds while making others sick. Bird activity in sprayed areas dropped to about one-quarter of the prespray level, and sick birds had ChE depression that returned to normal in those that survived (Finley 1965).

Simulated field applications of phosphamidon were made to penned pheasants at 0.6 and 3.4 kg/ha (0.5 and 3.0 lb/acre). At the lower rate some birds became sick, but at the higher rate, 90% of the birds were killed or became immobilized (Zorb 1967*a*).

In Switzerland, the spraying of phosphamidon at 1.0 kg/ha (0.9 lb/acre) reduced bird populations up to 20–40% of the original level. All 18 broods of 5 species of birds that were checked were found dead (Schneider 1966). Jack pine forests, sprayed at 0.3 kg tech/ha (0.25 lb/acre), had an apparent reduction in bird numbers, specifically warblers (McLeod 1966). Other studies on spruce budworm control concluded that an aerial application at 0.3 kg/ha (0.25 lb/acre) may be hazardous to birds, especially with fine atomization of the spray.

Large-scale application of phosphomidon at 1.0 kg AI/ha (0.9 lb/acre) for the control of grey larch tortricid resulted in a number of dead birds, especially insectivorous passerines, within the first 48 h (Ciba Agrochemical Division 1967).

A ground application of phosphamidon to a mature lemon grove, at an unspecified rate, did not result in acute poisoning of adult or nestling mourning doves (Sachsse and Voss 1971).

Persistence and Hazard Evaluation: Phosphamidon is an insecticide and acaricide with systemic, contact, and stomach-poison activity. It is a broad-spectrum insecticide used to control numerous agricultural and forest pests. Phosphamidon is a moderately persistent insecticide with residues declining to less than 1 mg/kg within 10 days of application (Ciba Agrochemical Division 1967). In forests, phosphamidon was determined to have low persistence with half-lives in foliage, water, and soil of only a few days (Varty and Yule 1976). There are three primary mechanisms of degradation of phosphamidon. One of these pathways, which occurs in plants and animals, yields toxic metabolites (Geissbühler et al. 1971). The anti-ChE metabolites, although comparable to the parent compound in acute toxicity, are rapidly degraded (Vettorazzi 1976). Half-lives of phosphamidon in seawater were about 2 weeks, and degradation in soils depends on soil type and initial residues but generally occurs in less than 1 month (Voss and Geissbühler 1971). Residues in green foliage are rapidly metabolized with half-lives of 1–2 days (Voss and Geissbühler 1971). Little information is available on the bioconcentration potential of phosphamidon; however, its high water solubility suggests a relatively low potential to bioconcentrate.

Phosphamidon has high acute oral toxicity to birds and mammals; it is rapidly absorbed through the skin; and it has a moderate to high dermal toxicity. It is highly toxic to honey bees (Ciba Agrochemical Division 1967; Thomson 1982). It was not carcinogenic in rats fed over a 2-year period, and it did not produce neurotoxic effects in dogs, rats, and hens (Sachsse and Voss 1971). Dietary LC50's calculated for birds (Hill et al. 1975), as well as acute oral and dermal LD50's (Tucker and Crabtree 1970; Hudson et al. 1979), indicate relatively high toxicity. Field investigations have confirmed that applications of phosphamidon to forests at rates less than 0.6 kg/ha (0.5 lb/acre) may result in substantial avian mortality (Fowle 1972). Although this insecticide has relatively brief environmental persistence, several incidences of bird mortality associated with phosphamidon applications suggest a hazard to wildlife.

Pirimiphos-ethyl

CAS #23505-41-1

Toxicity Class: II **Use Class:** Not applicable

Chemical Name: *O*-[2-(Diethylamino)-6-methyl-4-pyrimidinyl] *O,O*-diethyl phosphorothioate

Common and Trade Names: Fernex, Primicid, Primotec, Solgard

Action: Insecticide

Properties: A pale-yellow liquid, very soluble in organic solvents and nearly insoluble in water (less than 1 mg/L).

Field Applications and Formulations: Pirimiphos-ethyl is a broad-spectrum organophosphorus insecticide used only on turf in the United States (Food and Drug Administration 1982; Thomson 1982). Foreign applications extend to other agricultural uses such as soil treatments and seed dressings (Berg 1982; Food and Drug Administration 1982; Thomson 1982). Formulations include an emulsifiable concentrate (4EC), granules (5 and 10%), and a wettable powder (20%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic cat	U	U	U	25–30		285
Guinea pig	U	U	U	50–100		285
Mouse	U	U	U	105		146
Rat	F	U	U	192		11
	U	U	U	140–200		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	1,000–2,000			11

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
	U	U	U			90-day feeding trial with "no effect" at 1.6 ppm in the diet	285

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Pirimiphos-ethyl is a broad-spectrum insecticide, particularly recommended for dipteran and coleopteran insect control (Eto 1974). It is registered for use in Florida as a foliar spray against sod webworms and chinch bugs (Berg 1982). Although its oxygen analog has anticholinesterase activity, its hydrolysis products are not expected to inhibit cholinesterase (Food and Drug Administration 1982). Soil residue half-lives for pirimiphos-ethyl range from 3 to 10 weeks, and it is rapidly degraded on leaf surfaces (Food and Drug Administration 1982). Its low water solubility suggests a possible high predicted bioconcentration factor.

Pirimiphos-ethyl is of moderate to high toxicity in laboratory mammals; however, toxicity data for birds are lacking. Because primiphos-ethyl is used only on turf in the United States, is used in relatively low volumes, and is relatively short-lived in the environment, potential environmental exposure to wildlife may be low. Adverse effects on wildlife resulting from pirimiphos-ethyl applications are not reported in the published literature.

Profenofos

CAS #41198-08-7

Toxicity Class: III **Use Class:** VI

Chemical Name: *O*-(4-Bromo-2-chlorophenyl) *O*-ethyl *S*-propyl phosphorothioate

Common and Trade Names: Curacron, Polycron, Prothiofos, Selecron

Action: Insecticide

Properties: A pale-yellow liquid, miscible with most organic solvents and soluble in water at 20 mg/L.

Field Applications and Formulations: Profenofos is a nonsystemic, broad-spectrum organophosphorus insecticide with contact and stomach-poison activity. It is principally used on cotton; however, it is being used experimentally on other crops. Profenofos is formulated as an emulsifiable concentrate (6EC).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rabbit	U	U	tech	700		11
Rat	U	U	tech	400		11
	U	U	0.719 kg/L (6 lb/gal)	662		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	tech	472			11
	U	U	0.719 kg/L (6 lb/gal)	192			11
Rat	U	U	U	1,610			146
	U	U	U	~3,300			285

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Profenofos is a nonsystemic insecticide with a broad spectrum of activity. Developed in 1973, it is a relatively new organophosphate and has both stomach-poison and contact activity (Thomson 1982). It is used on cotton in the United States to control chewing and sucking insects and mites, especially lepidoptera. Few data on its environmental fate and persistence are available. The predicted bioconcentration factor for profenofos is moderately high for an organophosphate, indicating the possibility for some bioconcentration.

Profenofos is moderately toxic to rats and rabbits. The acute dermal toxicity for rabbits is greater than its acute oral toxicity. Profenofos is reported to be toxic to wildlife, fish, and bees (Worthing 1979; Thomson 1982) and highly toxic to birds (Worthing 1979). More toxicity data are needed to adequately assess the potential hazard to wildlife species. There are no published reports relating the use of profenofos to wildlife die-offs. The relatively low number of acres treated with profenofos may minimize wildlife exposure to this chemical.

Propetamphos

CAS #31218-83-4

Toxicity Class: II **Use Class:** Not applicable. Restricted

Chemical Name: Isopropyl (*E*)-3-hydroxycrotonate, *O*-ester with *O*-methyl ethylphosphoramidothioate

Action: Insecticide

Common and Trade Names: Safrotin

Properties: A yellow liquid, soluble in most organic solvents and in water at 110 mg/L.

Field Applications and Formulations: Propetamphos is an organophosphorus contact and stomach-poison insecticide used to control structural, household, and public health pests. Formulations include aerosol (2%), emulsifiable concentrate (50%), liquid (1%), and powder (2%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	U	119		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	U	U	2,300			11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Propetamphos is a nonsystemic insecticide used primarily to control cockroaches, flies, mosquitos, and other household or structural pests. Propetamphos has long residual activity, lasting up to 15 weeks (Thomson 1982). Thermostability of this compound is good, and hydrolytic stability is dependent on pH (Berg 1982). It is generally not applied in the environment for crop or forest protection, and there are no reports of wildlife die-offs resulting from the use of propetamphos. Use patterns of propetamphos suggest low exposure to wildlife species.

Propoxur

CAS #114-26-1

Toxicity Class: II **Use Class:** V

Chemical Name: *o*-Isopropoxyphenyl methylcarbamate

Common and Trade Names: Aprocarb, Baygon, Blattanex, Isocarb, PHC, Propion Unden, Propyon, Sendran, Suncide, Tugon Fliegenkugel, Unden, Undene

Action: Insecticide

Properties: A white to tan crystalline powder soluble in most organic solvents and in water at 2,000 mg/L. It is compatible with nonalkaline insecticides and fungicides (Berg 1982).

Field Applications and Formulations: Propoxur is a nonsystemic, fast-acting carbamate insecticide with contact and stomach-poison activity. Primary agricultural applications are on rice, although it is also used to control structural pests, mosquitos, and pests on agricultural or commercial premises. Propoxur is formulated as bait, dust (2%), emulsifiable concentrates (1.5EC, 20%), oil soluble, and wettable powders (50 and 70%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic goat	M	12	97	>800		131
Guinea pig	U	U	U	40		285
Mouse	M	U	U	100–109		285
Mule deer	F	11	97	100–350		131
Rat	M	A	tech	83	(66–104)	80
	F	A	tech	86	(67–110)	80
California quail	F	3–7	97	25.9	(14.9–45.0)	131
Chukar	M/F	4–6	98	23.8	(20.0–28.3)[a]	131
Dark-eyed junco	M	A	97	4.76	(4.00–5.70)[a]	131
European starling	U	U	U	15		225
House finch	M/F	A	97	3.55	(2.25–5.69)	131
House sparrow	F	U	97	12.8	(9.26–17.8)	131
Japanese quail	F	20	97	28.3	(20.0–40.0)[a]	131
Canada goose	M/F	U	97	5.95	(4.89–7.24)	131
Sandhill crane	M/F	U	97	>60		131
Mallard	F	4–6	98	11.9	(10.0–14.1)[a]	131
	F	4–6	98	9.4	(7.49–11.9)	131
Mourning dove	M/F	U	97	4.2	(3.54–5.00)[a]	131
Red-winged blackbird	U	U	U	3.8	(1.7–5.2)	225
Ring-necked pheasant	M	3–5	98	20	(10–40)	131
Rock dove	M/F	U	97	60.4	(38.0–96.1)	131

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Sharp-tailed grouse	F	12–48	97	120	(84.8–170)[a]	131
Bullfrog	M	U	97	595	(500–707)[a]	131

[a]Range from highest dosage producing no mortality to lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	M	U	tech	>500			11
Rat	M	U	tech	>5,000			11
	M/F	U	U			250 ppm in the diet resulted in no ill effects after 2 years	285
Japanese quail	U	0.5	95		>5,000	10% mortality at 5,000 ppm	124
Mallard	U	0.3	95		<1,000	75% mortality at 1,000 ppm	124
Northern bobwhite	U	0.5	95		206	(168–251)	124
Ring-necked pheasant	U	0.3	95		1,750		124

Effects of Field Applications and Field Tests on Wildlife: Applications of propoxur, at rates of 213 and 426 g/ha (3 and 6 oz/acre), have been reported to cause decreases in bird numbers (McEwen 1982). Other occurrences of possible effects or evidence of direct mortality are not found in the published literature.

Persistence and Hazard Evaluation: Propoxur is a nonsystemic insecticide with moderately low field use and non-field applications both in and around agricultural or commercial buildings. Its insecticidal activity includes fast effectiveness as well as some systemic activity (Kuhr and Dorough 1976). Propoxur, applied to soil, is fairly resistant to degradation and high percentages of initial residues may remain after 30 days (Kuseske et al. 1974). Residual insecticidal activity may last from 4 to 6 weeks (Kuhr and Dorough 1976). The bioconcentration potential of propoxur, predicted from water solubility, is low.

Propoxur has extreme acute oral toxicity to wild birds and has moderately acute toxicity to mammals. Subacute dietary toxicity to birds shows variability among species. Reversibility of cholinesterase activity inhibition is apparent shortly after exposure and also varies among species (Vettorazzi 1976). Propoxur's toxicity to birds, fish, and honey bees has been reported in several sources. Field use of propoxur is largely on rice, suggesting probable exposure to birds through feeding; however, there have been no reports of wildlife die-offs associated with the use of this insecticide. Decreases in bird numbers have been associated with propoxur use, but causes of these declines have not been specified (McEwen 1982). It is apparent that an acute propoxur exposure may result in bird mortality; however, its subacute toxicity, at least to some bird species, is much lower and may relate to species differences in the reversibility of cholinesterase inhibition. Because of its moderately low field use, exposure to wildlife is likely minimized; however, notable effects on bird numbers have been reported.

Ronnel

CAS #299-84-3

Toxicity Class: IV **Use Class:** Not applicable

Chemical Name: *O,O*-Dimethyl *O*-(2,4,5-trichlorophenyl) phosphorothioate

Common and Trade Names: Ectoral, Etrolene, Fenchlorfos, Fenchlorphos, Korlan, Nankor, Trolene, Viozene

Action: Insecticide

Properties: A white crystalline powder, miscible in most organic solvents and in water at 44 mg/L.

Field Applications and Formulations: Ronnel is an organophosphorus livestock insecticide also used on agricultural premises and for structural pest control. It controls many types of pests and is formulated as an aerosol (2.5%), emulsifiable concentrate (2EC), granules (5%), pour-on (0.240 kg/L; 2 lb/gal), and as a smear (5%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	>500		146
Mouse	U	U	U	2,000		146
Rabbit	U	U	U	640		146
Rat	M	A	tech	1,250		80
	F	A	tech	2,630		80
European starling	U	U	U	375	(158–890)	225
Mallard	M	3	92.5	≥2,000		131
Red-winged blackbird	U	U	U	80	(65–103)	225
Ring-necked pheasant	M	3–4	92.5	611	(351–1,063)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	1,000–2,000			11
Rat	M	A	tech	>5,000			80
	F	A	tech	>5,000			80
Japanese quail	U	0.5	98		>5,000	No overt signs of toxicity to 5,000 ppm	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: The production of ronnel has been discontinued by the manufacturer (Berg 1982). Ronnel was the first systemic livestock insecticide produced and controls grubs, lice, ticks, and other insects on cattle by oral administration (Eto 1974). It has low mammalian toxicity; however, acute oral LD50's for birds show marked variability. Potential exposure to wildlife appears low, and incidences of ronnel applications resulting in adverse effects on wildlife species have not been reported in the literature.

Sulfotep

CAS #3689-24-5

Toxicity Class: I **Use Class:** Not applicable. Restricted

Chemical Name: Tetraethyl thiopyrophosphate ($[(H_5C_2)_2P(S)]_2O$)

Common and Trade Names: Bladafum, Dithio, Dithione, Sulfotepp, Thiotepp

Action: Insecticide, acaricide

Properties: A light-yellow liquid, miscible in most organic solvents and soluble in water at 25 mg/L.

Field Applications and Formulations: Sulfotep is an organophosphorus insecticide and acaricide with high contact and fumigant activity. It is formulated as a fumigant and used in greenhouses to control insects and mites.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	7–10		11
European starling	U	U	U	100		225
Red-winged blackbird	U	U	U	400		225

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Sulfotep is an insecticide and acaricide used primarily in greenhouses to control aphids, spider mites, and other pests (Berg 1982). It is also effective against mollusks (Eto 1974). Sulfotep has high contact and fumigant action and is highly toxic to mammals. Its acute oral toxicity to birds is moderately high based on the two species tested (Schafer 1972). Because of its limited use as a greenhouse fumigant, exposure to wildlife species is likely minimal. There have been no reported wildlife incidences involving the use of sulfotep.

Sulprofos

CAS #35400-43-2

Toxicity Class: II **Use Class:** V. Restricted

Chemical Name: *O*-Ethyl *O*-[*p*-(methylthio)phenyl] *S*-propyl phosphorodithioate

Common and Trade Names: Bolstar, Helothion, Merpafos

Action: Insecticide

Properties: A tan-colored liquid, soluble in organic solvents and in water at <20 mg/L.

Field Applications and Formulations: Sulprofos is an organophosphorus insecticide with a narrow spectrum of activity. It is used primarily on cotton to control lepidoptera and experimentally on corn and other crops (Thomson 1982). Cotton is the only crop receiving a significant amount of applications. It is formulated as an emulsifiable concentrate (6EC).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	107		11
	M	U	U	304		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	1,200			285
			U			A 3-generation feeding study at 0, 30, 60, and 120 ppm in the diet resulted in no reproductive or teratogenic effects; "no observed effect" level was equivalent to 6 mg/kg body weight per day	107
Rabbit	U	U	tech	820			11
Mallard egg			U			External application produced teratogenic effects	126
Japanese	U	0.5	99		477	(402–571)	122
quail	U	0.5	64EC		367	(305–436)	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Sulprofos is a selective contact insecticide used primarily on cotton. Half-lives of sulprofos range from 1 to 4 weeks in surface-treated soils and from 2 to 20 weeks when incorporated into the soil (Food and Drug Administration 1982). Major degradation products include phenol sulfoxide, sulprofos sulfoxide, and sulprofos sulfone, all with half-lives greater than 128 days (Food and Drug Administration 1982). The oxygen analog and sulfoxide and sulfone metabolites are ChE inhibitors (Food and Drug Administration 1982). Few studies have been done on the environmental fate of sulprofos following field applications. The bioconcentration factor, predicted from water solubility, is moderate when compared with other organophosphates.

Sulprofos appears to be of moderately acute toxicity to laboratory mammals, and avian toxicity data are not available. Delayed neurotoxic effects were not observed in hens following dosages of up to 250 mg/kg body weight (Food and Drug Administration 1982). Wildlife die-offs or other wildlife problems resulting from the use of sulprofos have not been reported in the literature. Little is known about potential bioconcentration of sulprofos in terrestrial and aquatic environments. The lack of toxicity data for wild bird and mammal species precludes an evaluation of its potential risk to wildlife.

Temephos

CAS #3383-96-8

Toxicity Class: IV **Use Class:** VI

Chemical Name: *O,O'*-(Thiodi-*p*-phenylene) bis[*O,O*-methyl phosphorothioate]

Common and Trade Names: Abate, Abathion, Difenthos, Ecopro, Nimitox, Swebate

Action: Insecticide

Properties: Technical temephos is a white, crystalline solid that is highly stable when stored at room temperature.

Field Applications and Formulations: Temephos is an organophosphorus insecticide used to control mosquito, midge, and black-fly larvae in lakes, ponds, and wetland habitats. The annual acre-treatments of temephos for mosquito control are substantial. It is formulated as an emulsifiable concentrate (4EC), granules (1, 2, and 5%), and a water dispersible powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	4,000		146
Rat	M	A	tech	8,600	(7,166–10,320)	80
	F	A	tech	13,000	(11,304–16,250)	80
	U	U	tech	2,030		11
California quail	F	6	92	18.9	(15.0–23.8)	131
Chukar	M/F	2–3	92	270	(170–429)	264
	M/F	2–3	92	240	(110–521)	131
European starling	U	U	U	>100		225
House sparrow	F	A	92	35.4	(8.85–141)	131
Japanese quail	M	2	92	84.1	(60.6–116)	264
	U	U	U	75.0		228
Mallard	M/F	U	92	80–100		264
	M	4–7	92	79.4	(38.5–163)	131
Red-winged blackbird	U	U	U	42.2		228
Ring-necked pheasant	F	3–4	92	31.5	(18.1–54.9)	264
	F	3–4	92	35.4	(25.5–49.0)	131
Rock dove	M/F	U	92	50.1	(16.7–150)	131, 264
Bullfrog	F	U	92	>2,000		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	tech	970–1,930			11
	U	U	U	1,024–1,782			146
Rat	M	A	tech	>4,000			80
	F	A	tech	>4,000			80
Japanese quail	U	0.5	86.8		257	(207–318)	122
	U	0.5	44.7		288	(249–333)	122
Mallard	U	0.5	86.8		894	(575–1,910)	124
	U	12–24 h	4E			Diets up to 10 ppm did not directly affect duckling survival; at 100 ppm its toxic effect was enhanced by cold	72
Northern bobwhite	U	0.5	86.8		92	(70–117)	124
Ring-necked pheasant	U	0.3	86.8		162	(120–207)	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Temephos is widely used as a mosquito and midge larvicide, but may also be mixed with other insecticides to obtain a broader spectrum of activity (Thomson 1982). It is commonly used by municipal mosquito-control programs.

Few data exist on the environmental persistence of temephos, but the information available suggests low persistence under most conditions. Ten weekly applications of the 4E formulation, at twice the normal application rate, resulted in the rapid disappearance of residues from pond water and mud (Bowan and Orloski 1966). At 20 times the normal application rate, 1.1 kg AI/ha (1.0 lb/acre), samples of pond water taken one week after treatment contained only trace amounts of the chemical. Temephos is hydrolyzed below pH 2 and above pH 9 (Worthing 1979). It is stable in both fresh and saline water at 25°C (Worthing 1979).

Temephos has low mammalian toxicity, with acute oral LD50's ranging from 1,000 to 13,000 mg/kg. Its acute toxicity to birds is greater, with oral LD50's from about 30 to 270 mg/kg. There are few data on its dermal toxicity. Mallard ducklings (12–24 h of age) were fed diets treated with temephos for 7 days and housed in either heated or unheated brooders. High mortality occurred in the 100-ppm group housed in unheated brooders, but diets containing up to 10 ppm did not affect duckling survival (Fleming et al. 1985).

A reproductive study conducted with game-farm mallards fed 0, 1, and 10 ppm Abate 4E did not result in treatment effects for hatching success, clutch size, fertility, nest attentiveness of incubating hens, and duckling avoidance behavior. However, the mean interval between eggs laid was greater for the 10-ppm group, and duckling survival to 21 days was significantly lower for both treatment groups than for controls (Franson et al. 1983).

Temephos is toxic to certain species of aquatic invertebrates, shrimp, and crabs (Mulla et al. 1979; Thomson 1982); however, information on its toxicity to bees and fish is conflicting (Mulla et al. 1979; Thomson 1982). There have been no published accounts of wildlife die-offs that relate to field applications of temephos.

TEPP

CAS #107-49-3

Toxicity Class: I **Use Class:** VI. Restricted

Chemical Name: Tetraethyl pyrophosphate

Common and Trade Names: Kilmite 40, Nifos T, TEP, Tetron, Vapotone

Action: Insecticide, acaricide

Properties: A colorless, hygroscopic liquid, miscible with water and rapidily hydrolyzed by water.

Field Applications and Formulations: TEPP is a contact organophosphorus insecticide and acaricide used to control aphids, mites, and other soft-bodied insects in the active stages. Its extreme toxicity has led to use restrictions, and its present importance as an insecticide is largely historical (Eto 1974).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	1–7		146
Rat	M	A	tech	1.05	(0.91–1.21)	80
Chukar	M/F	3–4	40[a]	10.1	(7.28–14.0)	264
Mallard	M	3–4	40[a]	3.56	(2.70–4.68)[b]	131
Ring-necked pheasant	M	3–4	40[a]	4.22	(2.93–6.09)	264
Bullfrog	F	U	40[a]	89.1	(46.3–171)	264
	F	U	40[a]	112	(70.7–178)	131

[a]40% Tepp, 60% other ethyl phosphates.
[b]Range of highest dosage producing no mortality to lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	A	tech	2.4		(2.1–2.7)[a]	80
Japanese	U	0.5	99		1,517	(1,258–1,828)	122
quail	U	0.5	40		403	(308–529)	122
Mallard	M	14–15	40[b]	64.0		(28.7–142)[a]	130

[a]95% CL for acute dermal LD50.
[b]40% Tepp, 60% other ethyl phosphates.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: The production of TEPP has been discontinued by the manufacturer (Berg 1982) although there is still current registration for some products (Office of Pesticide Programs 1982). TEPP was the first commercially marketed organophosphate insecticide (Eto 1974) and has the highest mammalian toxicity of all of the organophosphates. It has been used to control several species of insects and mites, but its current use is extremely restricted and only a small number of acres of apples show any recent applications. Reports of wildlife die-offs caused by TEPP are not found in the literature, and wildlife exposure is likely minimal. Restrictions on the use of this pesticide and the low number of acres treated probably minimize wildlife exposure to this extremely toxic chemical.

Terbufos

CAS #13071-79-9

Toxicity Class: I **Use Class:** II

Chemical Name: *S*-[(*tert*-Butylthio)methyl] *O*,*O*-diethyl phosphorodithioate

Common and Trade Names: Counter

Action: Soil insecticide, nematicide

Properties: Technical terbufos is a colorless to pale-yellow liquid with a water solubility of about 10 mg/L. It is hydrolyzed under alkaline conditions and is stable at room temperature for 2 years (Berg 1982).

Applications and Formulations: Terbufos is an organophosphorus soil insecticide and nematicide that has initial and residual activity against soil insects and other arthropods. Used primarily on corn, sween corn, and sugar beets, it is now being tested on other crops. The major crop is corn. Terbufos is formulated as granules (15%) and applied at the time of planting in a band or in the seed furrow.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	M	U	tech	4.5		11
	F	U	tech	6.3		11
Mouse	M	U	tech	3.5		11
	F	U	tech	9.2		11
Rat	M	U	tech	4.5		11
	F	U	tech	9.0		11
Northern bobwhite	M/F	A	tech	15	(12–19)	121
	M/F	A	15G	26	(20–34)	121

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			6-month feeding trial at an unspecified level with "no effect" except ChE depression	285
Mouse	U	U	U			18-month feeding trial at an unspecified level with "no effect" except ChE depression	285
Rabbit	U	U	tech and 15G			24-h skin contact LD50 was 1.1 mg/kg (tech) and 29–34mg/kg (15G)	11
Rat	U	U	15G			24-h skin contact LD50 was 900–1,425 mg/kg	11
Japanese	U	0.5	99		284	(239–342)	122
quail	U	0.5	15G		225	(194–265)	122

Effects of Field Applications and Field Tests on Wildlife: Confined ring-necked pheasant hens were exposed to terbufos pressed into the soil at rates of 1.1 and 5.7 kg tech/ha (1 and 5 lb/acre). Birds were exposed dermally through dusting behavior in treated soil and possibly through ingestion and inhalation, but no direct observations of ingestion were made. No mortality or signs of acute or chronic organophosphate poisoning were observed (Labisky 1975).

Persistence and Hazard Evaluation: Residues of terbufos in corn forage were determined following band-furrow treatments at 1.1, 2.3, and 4.5 kg AI/ha (1, 2, and 4 lb/acre, respectively). Residues ranged from nondetectable amounts (for 1.1 kg/ha) at 60 days to 0.43 mg/kg at 40 days after treatment (for 4.5 kg/ha; Sellers et al. 1976). The half-life of the parent compound has been reported to be 2 weeks for sandy loam soils (Labisky 1975). Laboratory tests determined the half-life of the parent compound to be 4–5 days and that it is rapidly oxidized to its sulfoxide (Laveglia and Dahm 1975). Field and laboratory data indicate that the persistence and bioconcentration of this insecticide is relatively low.

Terbufos is extremely toxic to laboratory mammals, both orally and dermally. Currently, few toxicity data are available for avian species. One simulated field exposure to penned pheasants resulted in no obvious poisoning or mortality of birds (Labisky 1975); however, this study did not report if ingestion of the granules pressed into the soil had occurred (Labisky 1975). It appears that if applied properly, wildlife exposure would be minimal. However, spillage, failure to cover granules, heavy rains, or high winds could expose granules and result in wildlife exposure.

Tetrachlorvinphos

CAS #22248-79-9[1]

Toxicity Class: IV **Use Class:** VI

[1]Tetrachlorvinphos with an unspecified geometry of the double bond is CAS #961-11-5.

Chemical Name: (*Z*)-2-Chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate

Common and Trade Names: Appex, Gardcide, Gardona, Rabon, Rabond, Stirifos

Action: Insecticide

Properties: An off-white crystalline solid, soluble in most aromatic hydrocarbons and in water at 11 mg/L.

Field Applications and Formulations: Tetrachlorvinphos is an insecticide with contact with stomach-poison activity. It is applied to fruits, corn, vegetable crops, livestock, and to agricultural and recreational premises. It is formulated in dust (3%), emulsifiable concentrate (2EC), granules, oil solution (0.479 kg/L; 4 lb/gal), and wettable powders (50 and 75%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	>4,000		146
Rat	U	U	U	4,000–5,000		11
Chukar	M/F	2–3	tech	≫2,000		131
Mallard	M/F	3–5	tech	≫2,000		131
Ring-necked pheasant	M/F	2–4	tech	⩾2,000		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			2-year feeding trial with no effects at 200 ppm in the diet	285
Rabbit	U	U	U	>2,500			11
Rat	U	U	U			2-year feeding trial with no effects at 125 ppm in the diet	285
Japanese quail	U	0.5	96		>5,000	No mortality to 5,000 ppm	124
Mallard	U	0.3	96		>5,000	No mortality to 5,000 ppm	124
Ring-necked pheasant	U	0.3	96		>5,000	No mortality to 5,000 ppm	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Tetrachlorvinphos is a selective insecticide with stomach-poison and contact activity. It is a moderately persistent organophosphate (Maclean 1972), and degradation products do not have anticholinesterase activity (Beynon and Wright 1969). Initial half-lives of tetrachlorvinphos on foliage and in medium loam soils were 1 and 4–5 days, respectively (Beynon and Wright 1969). The predicted bioconcentration factor for tetrachlorvinphos is low, and studies have confirmed that bioconcentration is probably negligible (Food and Drug Administration 1982).

Tetrachlorvinphos is of slight toxicity to birds and mammals. Acute oral and dermal LD50's are high and dietary exposure to birds also indicates very low toxicity. Studies done with white mice have shown that tetrachlorvinphos does not produce delayed neurotoxic effects in that species (El-Sebae et al. 1977). Field applications of this insecticide have not been associated with adverse effects on wildlife. The relatively low number of total acres treated with tetrachlorvinphos and its low potential to bioconcentrate suggest an overall low potential for wildlife exposure.

Trichlorfon

CAS #52-68-6

Toxicity Class: II **Use Class:** V

Chemical Name: Dimethyl (2,2,2-trichloro-1-hydroxyethyl)phosphonate

Common and Trade Names: Anthon, Bovinox, Briten, Cekufen, Cekufon, Chlorofos, Chlorophos, Ciclosom, Crinex, Danex, Dipterex, Dylox, Equino-Aid, Leivasom, Masoten, Neguvon, Proxol, Trichlorophon, Trichlorphon, Trinex, Tugon

Action: Insecticide, anthelmintic

Properties: A white crystalline solid, slightly soluble in aromatics and soluble in water at 154,000 mg/L.

Field Applications and Formulations: Trichlorfon is an organophosphorus insecticide with contact and stomach-poison activity. It is used on several types of crops, for livestock ectoparasite control, and as an anthelmintic in animals. The major field crops include alfalfa and cotton, with beans, sorghum, and corn receiving some use. It is also used as a forest spray to control budworms and gypsy-moth larvae. Trichlorfon is formulated as bait, dust (5%), soluble concentrates (250, 500, and 700 g/L), and soluble powders (40, 50, 80, and 95%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	M/F	U	tech	950		35
Rat	M	A	tech	630		80
	F	A	tech	560		80
	U	U	tech	144–184		11
California quail	F	9–11	98	59.3	(47.1–74.7)	131
European starling	U	U	U	43.0		228
Mallard	F	3–4	98	36.8	(26.6–51.1)	131
Northern bobwhite	F	10	98	22.4	(13.3–37.6)	131
Red-winged blackbird	U	U	U	37.0–75.0		228
Ring-necked pheasant	M	4	98	95.9	(76.1–121)	131
Ringed turtle-dove	F	A	98	32.0	(26.9–38.0)[a]	131
Rock dove	M/F	A	98	123	(78.1–195)[a]	131

[a]Range of highest dosage producing no mortality to lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	A	tech	>2,000			80
	F	A	tech	>2,000			80

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat			U			Rats were fed 0, 50, 250, 500, and 1,000 ppm; a decrease in life span in both sexes and a decreased weight gain in males was observed at 1,000 ppm; a 3-generation reproductive study noted decreased fertility and litter sizes at 1,000 ppm	75
Japanese quail	U	0.5	98		1,899	(1,510–2,388)	122
Mallard	U	0.3	98		>5,000	No mortality to 1,581 mg/kg, 30% at 5,000 mg/kg	124
Northern bobwhite	U	0.3	98		720	(591–871)	124
Ring-necked pheasant	U	0.3	98		3,401	(2,927–3,957)	124

Effects of Field Applications and Field Tests on Wildlife: Trichlorfon diluted in Panasol AN3 oil at the rate of 1.1 kg in 9.4 L/ha (1 lb AI/acre) was aerially applied to forests to control western budworms. Bird populations studied before and up to 14 days after spraying did not exhibit a significant decrease in numbers. Sick and dead birds were not found after spraying (DeWeese et al. 1979), and spraying had little effect on brain cholinesterase activities in birds (Zinkl et al. 1977).

A review of applications of trichlorfon at 284 to 852 g/ha (4.0 to 12.0 fl oz/acre) to rangelands found no reported effects on wildlife (McEwen 1982).

Persistence and Hazard Evaluation: Trichlorfon is a contact and stomach-poison insecticide used on agricultural crops and forests. It is also used externally and internally on animals to control parasites. Half-lives for trichlorfon applied to green plants are about 1–2 days (Food and Drug Administration 1982). Following a forest application, residues reported for leaves, twigs, and litter declined rapidly over the first 7 days but were still detectable at 106 days after spraying. Twelve days after granular application to pasture at 1.1, 2.8, and 5.7 kg AI/ha (1, 2.5, and 5 lb/acre) residues were 1, 2, and 5 mg/kg, respectively (Solly 1968). Pastures sprayed with trichlorfon at 1.1 and 2.3 kg AI/ha (1 and 2 lb/acre) had residues of 1 and 5 mg/kg at 12 days, respectively (Solly 1968). Degradation of trichlorfon occurs through the splitting of the Phosphorus-Carbon (P-C) bond and through hydrolysis of the P-OCH bonds resulting in trace amounts of dichlorvos, a more acutely toxic organophosphate (Vettorazzi 1976; Food and Drug Administration 1982). Trichlorfon is highly soluble in water and has an extremely low predicted bioconcentration factor (Kenaga 1980). It is readily absorbed, degraded, and excreted by mammals (Food and Drug Administration 1982).

Trichlorfon's acute toxicity ranges from slightly to extremely high in mammals and birds. Acute oral LD50's for rats and birds are highly variable. Dietary 5-day feeding studies with birds determined LC50's indicating relatively low subacute toxicity to the species tested (Hill et al. 1975). Information on field applications of trichlorfon suggest that effects on wildlife are likely minimal when properly applied. Trichlorfon is toxic to bees (Thomson 1982). Most studies to date have shown trichlorfon to have a low mutagenic and teratogenic potential; however, increases in the incidence of mammary tumors were found in some studies done with rats (Food and Drug Administration 1982). Because of trichlorfon's hydrophilic properties, it is readily metabolized and excreted by animals, and its environmental persistence and bioconcentration potential are low. Trichlorfon has been found to potentiate the toxicity of EPN, malathion, and azinphos-methyl (Food and Drug Administration 1982). Possible interactions of these pesticides should be considered prior to its use. Wildlife die-offs associated with the use of trichlorfon have not been reported in the literature.

Herbicides

Asulam

CAS #3337-71-1

Toxicity Class: V **Use Class:** V

Chemical Name: Methyl sulfanilylcarbamate

Common and Trade Names: Asilan, Asulox, Jonnix

Action: Herbicide

Properties: Colorless crystals soluble in water at 4,000 mg/L.

Field Applications and Formulations: Asulam is a selective postemergence carbamate herbicide used to control several species of perennial grasses and a variety of weeds. It is applied as a broadcast spray using aerial or ground equipment. Asulam is absorbed by roots and leaves and causes chlorosis of the treated plant. The major agricultural crop is sugarcane, and it is also used in reforestation and in Christmas tree plantations. Asulam is formulated as a liquid concentrate (0.400 kg/L; 3.34 lb/gal) and marketed as the aqueous solution of the sodium salt.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	>4,000		285
Rabbit	U	U	U	>4,000		285
Rat	U	U	U	>8,000		12
	U	U	tech	>5,000		11
Mallard	U	U	U	>4,000		133
Gray patridge	U	U	U	>2,600, <4,000		133
Quail, unspecified	U	U	U	>2,000		285
Ring-necked pheasant	U	U	U	>4,000		133
Rock dove	U	U	U	>4,000		133

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			Repeated daily oral doses of 500 mg/kg had "no adverse effects"	12

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	>1,000			12
Northern bobwhite	M/F	5–7	98.6			Dietary levels up to 25 ppm in the diet fed to birds for 28 days did not adversely affect food consumption, growth rate, mortality, or reproduction; it was not teratogenic at this level	81
Ring-necked pheasant	M/F	0.25	U			No mortality at 8 days at dietary concentrations up to 75 g/kg	133

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Asulam is a selective herbicide applied as a postemergence spray. It is absorbed by roots and leaves and translocated through the plant where it likely affects meristematic growth (Beste 1983). Asulam has a relatively short persistence in soils with a half-life of 6–14 days (Beste 1983). Its predicted bioconcentration factor is very low.

Asulam has slight acute oral toxicity to laboratory mammals and wild birds. Its dermal and chronic oral toxicities also appear to be low for mammals and birds. Available information suggests that this herbicide is relatively safe to both fish and wildlife (Ingham and Gallo 1975; Thomson 1982; Beste 1983), and there are no reported incidences of asulam use resulting in adverse effects on wildlife.

Barban

CAS #101-27-9

Toxicity Class: IV **Use Class:** IV

Chemical Name: 4-Chloro-2-butynyl *m*-chlorocarbanilate

Common and Trade Names: Barbamate, Barbane, Carbyne, Chlorinat, Neobyne, Wypout

Action: Herbicide

Properties: A crystalline solid, soluble in water at 11 mg/L.

Field Applications and Formulations: Barban is a selective postemergence carbamate herbicide applied as a foliar spray. It is used to control wild oats, primarily in wheat, and also has some activity against weeds, including smartweeds (Polygonaceae). Barban is formulated in emulsifiable concentrates (1 and 2EC).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	1,350		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U	23,500			12

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Barban is a selective postemergence herbicide applied as a foliar spray. It is not readily translocated throughout the plant (Beste 1983), and it has relatively low environmental persistence. It is primarily degraded through microbial activity, and residues in soils are reduced to trace amounts within 3 weeks (Beste 1983). Barban has a moderately low potential to bioconcentrate.

Barban is of low acute oral and dermal toxicity in laboratory rats. Toxicity data are not available for wildlife species. Anticholinesterase activity has not been reported for this herbicide, and its chronic toxicity appears to be low for rats (Beste 1983). Barban has moderate field use and is relatively nonpersistent. Barban has not been reported to cause adverse effects in wildlife.

Bensulide

CAS #741-58-2

Toxicity Class: III **Use Class:** VI

Chemical Name: *O,O*-Diisopropyl hydrogen phosphorodithioate, *S*-ester with *N*-(2-mercaptoethyl)benzenesulfonamide

Common and Trade Names: Betasan, Disan, Exporsan, Prefar, Pre-San

Action: Herbicide

Properties: An amber liquid soluble in water at 25 mg/L.

Field Applications and Formulations: Bensulide is a selective, pre-emergence organophosphorus herbicide. It is applied to crops as a preplant treatment incorporated into the soil or as a soil-surface application. It is applied to turf to control crabgrass and other weeds. Relatively few agricultural acres are treated with this herbicide. Bensulide is formulated as an emulsifiable concentrate (4EC) and as granules (3.6, 7, 10, and 12.5%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	tech	271–1,470		11
	U	U	U	770		272
	U	U	0.479 kg/L (4 lb/gal)	826–1,778		272
	U	U	3.6G	>1,000		272
	U	U	12.5G	2,650		272.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	tech	3,950			272

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	0.479 kg/L (4 lb/gal)	10,000			272
	U	U	10G	>5,000			272
Rat						90-day feeding study "no effect" level was 25 mg/kg per day	272
Japanese quail	U	U	U			21-day feeding study "no effect" level was 10 mg/kg per day	272

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Bensulide is a pre-emergence organophosphorus herbicide with long residual activity. It is one of the few organophosphorus compounds marketed as a herbicide, not an insecticide, and its herbicidal mechanism of action is unknown (Weed Science Society of America 1979). Bensulide is a relatively persistent organophosphate with soil half-lives of about 4–6 months (Weed Science Society of America 1979). Its residual activity has been reported to last up to 12 months (Eto 1974). Its predicted bioconcentration factor indicates a moderate potential to bioconcentrate (Kenaga 1980). Bensulide is absorbed by roots, but little is translocated to the leaves, except as metabolites (Weed Science Society of America 1979; Worthing 1979).

Bensulide is of moderate to low mammalian toxicity. Formulations appear to be generally less toxic than the technical material, and acute dermal toxicity is also low. Apparently little toxicity testing has been done with birds for bensulide, and its acute avian toxicity is largely unknown. Bensulide toxicity to mammals is relatively low, but it does have anticholinesterase activity and atropine is antidotal. There have been no published reports of adverse effects to wildlife associated with bensulide use. Agricultural acreages treated with this chemical are relatively low; however, application rates of bensulide are relatively high, up to 22.6 kg/ha (20 lb/acre; Weed Science Society of America 1979).

Butylate

CAS #2008-41-5

Toxicity Class: IV **Use Class:** I

Chemical Name: *S*-Ethyl diisobutylthiocarbamate

Common and Trade Names: Sutan, Sutan + (butylate combined with R-25788)

Action: Herbicide

Properties: The technical product is a clear liquid with an aromatic odor, soluble in water at 45 mg/L.

Field Applications and Formulations: Butylate is a selective preplant carbamate herbicide used to control most grassy weeds and some broad-leaved weeds. It is incorporated into the soil and often combined with other herbicides or fertilizers. The major crop is corn. Butylate is formulated as an emulsifiable concentrate (0.803 kg/L; 6.7 lb/gal) and in granules (5 and 10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	M	U	tech	1,659		12

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	4,659		12
	F	U	tech	5,431		12
	M	U	6E	5,366		12
	F	U	6E	3,878		12
	U	U	U	3,500–5,431		11
Mallard	M	3	98	>2,000		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	>4,640			11
Northern	U	U	tech		40,000[a]		12
bobwhite	U	U	6E		27,000[a]		12

[a]7-day feed treatment.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Butylate is a selective pre-emergence herbicide and is the most widely used of the agricultural carbamate pesticides. Its agricultural use is almost exclusively on corn, and it is generally incorporated into the soil immediately after application. Butylate is taken up by plant roots and translocated through the plant where it inhibits meristematic growth (Beste 1983). It is nonpersistent, and half-lives in soils range from 1.5 to 3 weeks (Beste 1983). Butylate has a low predicted bioconcentration factor.

Butylate is of low acute toxicity to the mammal and bird species used in toxicity tests for this compound. Subacute tests also indicate low toxicity, and despite its wide field use, butylate has not been reported to cause adverse effects in wildlife species. Low environmental persistence and very low acute and subacute toxicity indicate a minimal potential hazard to wildlife species.

CDEC

CAS #95-06-7

Toxicity Class: III **Use Class:** VI

Chemical Name: 2-Chloroallyl diethyldithiocarbamate

Action: Herbicide

Common and Trade Names: Sulfallate, Vegedex

Properties: An amber oily liquid, soluble in water at 92 mg/L.

Field Applications and Formulations: CDEC is a selective pre-emergence carbamate herbicide applied to the soil surface or incorporated into the soil. It is used to control annual grasses and some broad-leaved weeds in several different crops. CDEC is formulated in granules (20%) and liquid (0.479 kg/L; 4 lb/gal).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	850		11
Ring-necked pheasant	U	U	U	>15,400		272

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog (beagle)	U	U	U			90-day dietary dosage of up to 200 ppm in the diet had no effects other than changes in liver/body weight ratios	272
Rabbit	U	U	U	2,200–2,800[a]			272
Mallard	U	I	U		>5,000		272
Northern bobwhite	U	I	U		>5,000		272

[a]Minimum lethal dose.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: CDEC production has been discontinued by the manufacturer (Berg 1982). Current use is estimated as being minimal and probably represents applications from existing stocks. CDEC is applied to the soil surface or is incorporated into soils and is not absorbed by plant foliage (Weed Science Society of America 1979). It is rapidly metabolized in plants and does not persist in soils beyond 3–6 weeks (Weed Science Society of America 1979). Its bioconcentration potential, predicted from water solubility, is low.

CDEC is of very low acute oral toxicity to ring-necked pheasants and has low subacute dietary toxicity to other avian species. It is of moderate acute oral toxicity in rats, and its dermal toxicity to rabbits is low. There have been no reports of CDEC use resulting in adverse effects in wildlife. The discontinuation of production, limited field use, and low toxicity of CDEC suggest a current minimal risk to wildlife.

Chlorpropham

CAS #101-21-3

Toxicity Class: IV **Use Class:** V

Chemical Name: Isopropyl *m*-chlorocarbanilate

Common and Trade Names: Beet-Kleen, Chloro-IPC, CIPC, Elbanil, Furloe, Navon, Nexoval, Prevanol, Sprout-Nip, Spud-Nic, Stopgerme-S, Taterpex, Triherbide-CIPC, Unicrop CIPC

Action: Herbicide

Properties: A solid that is soluble in lower alcohols, most organic solvents, aromatic hydrocarbons, and in water at 89 mg/L. It is subject to hydrolysis under acidic and alkaline conditions.

Field Applications and Formulations: Chlorpropham is a selective carbamate herbicide applied at preplant, and at pre- and postemergence. It is effective against many species of annual weeds, and its major use is on soybeans. Formulations include emulsifiable concentrates (3 and 4EC), flowable (0.479 kg/L; 4 lb/gal), and granules (10 and 20%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rabbit	U	U	tech	5,000		12
Rat	U	U	tech	3,800		12
	U	U	4EC	3,700		12
Mallard	F	3–4	99+	>2,000		131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	4EC	10,200			12
	U	U	U			2-year feeding study with "no effect" at 2,000 ppm in the diet	285
	U	U	U			3-generation study showed no terato-genic or reproductive effects	12

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Chlorpropham is a highly selective herbicide applied in granules to the soil and as a foliar spray. Degradation of chlorpropham in soils primarily occurs by microbial activity and half-lives vary from about 30 to 65 days (Beste 1983). The predicted bioconcentration potential of chlorpropham is low.

Chlorpropham has low acute oral and dermal toxicity to laboratory animals. The acute oral LD50 for mallards also indicates low toxicity. Anticholinesterase activity was not found at dietary levels up to 10,000 mg/kg in rats (Food and Drug Administration 1982). Reproductive or teratogenic effects have not been demonstrated in the rat at dietary levels of 0.2–0.5% (Beste 1983). Chlorpropham has weak tumor-initiating activity when applied dermally, but it does not have carcinogenic activity when fed to rats (Vettorazzi 1976).

Cycloate

CAS #1134-23-2

Toxicity Class: IV — **Use Class:** V

Chemical Name: *S*-Ethyl *N*-ethylthiocyclohexanecarbamate

Common and Trade Names: Hexylthiocarbam, Ro-Neet

Action: Herbicide

Properties: A clear liquid, miscible in most organic solvents and soluble in water at 85 mg/L.

Field Applications and Formulations: Cycloate is a selective preplant carbamate herbicide used to control annual broad-leaved weeds and grasses. It is incorporated into the soil immediately before planting. Principal use of cycloate is on sugar beets to control nutgrass, and formulations include an emulsifiable concentrate (6EC) and granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	2,000–3,190		12
	F	U	tech	3,160–4,100		12
	M	U	6EC	3,160		12
	F	U	6EC	3,690		12
European starling	U	U	U	Not orally toxic at 100 mg/kg		225
Red-winged blackbird	U	U	U	Not orally toxic at 100 mg/kg		225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			90-day feeding study had "no effect" at 240 mg/kg per day	12
Rabbit	U	U	6EC	>4,640			12
Rat	U	U	U			90-day feeding study had "no effect" at 55 mg/kg per day	12
Northern bobwhite	U	U	U		>56,000[a]		12

[a]7-day feed treatment.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Cycloate is a soil-incorporated, selective herbicide with moderately low field use. It is rapidly absorbed and translocated through the plant. Degradation in soils occurs mostly by microbial action, and when applied at recommended rates, half-lives for soil residues are about 4–8 weeks (Beste 1983). Cycloate does not persist in plants (Beste 1983), and its predicted bioconcentration is relatively low.

Cycloate is of low acute oral and dermal toxicity to laboratory mammals and was not orally toxic to starlings and blackbirds at 100 mg/kg (Schafer 1972). The subacute dietary toxicity of cycloate to quail is extremely low. Cycloate has low acute and subacute toxicity, limited field use, and short environmental persistence.

DEF

CAS #78-48-8

Toxicity Class: II **Use Class:** VI

Chemical Name: *S,S,S*-Tributyl phosphorotrithioate

Common and Trade Names: Butifos, De-Green, E-Z-off D, Fos-Fall 'A', Ortho Phosphate Defoliant

Action: Defoliant

Properties: A colorless to pale-yellow liquid soluble in most organic solvents and insoluble in water. It is hydrolyzed under alkaline conditions.

Field Applications and Formulations: DEF is an effective defoliant registered for use on cotton (Eto 1974; Berg 1982). It is formulated as an emulsifiable concentrate.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	A	tech	233	(206–263)	80
	F	A	tech	150	(125–180)	80
Mallard	M	3–4	92	2,934	(1,686–5,109)	131
Ring-necked pheasant	F	4	92	273	(191–390)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	A	tech	360		(288–450)[a]	80
	F	A	tech	168		(127–222)[a]	80

[a]95% CL for acute dermal LD50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: DEF is a cotton defoliant and an oxidation product of merphos, another defoliant. Little information is available regarding the environmental fate and persistence of DEF. Because it is insoluble in water, its bioconcentration potential is probably high, although experimental evidence is lacking.

DEF appears to be of moderate to low toxicity in species tested; however, acute oral LD50's show marked variability among species. Dose-related teratogenic or reproductive effects have not been observed (Food and Drug Administration 1982). Results of neurotoxicity studies are also variable; however, there is some evidence of neurotoxicity at high dietary levels (Food and Drug Administration 1982). There are no reports of DEF applications affecting wildlife species. Low agricultural use and restricted applications may minimize exposure to wildlife.

2,4-DEP

CAS #8005-49-0

Toxicity Class: III **Use Class:** VI

Chemical Name: 2-*sec*-Butyldinitrophenol, mixture with tris[2-(2,4-dichlorophenoxy)ethyl] phosphite

Common and Trade Names: Falodin, Falone

Action: Herbicide

Properties: Stable under anhydrous conditions and may be converted to the herbicide 2,4-D when hydrolyzed in soils (Eto 1974).

Field Applications and Formulations: Used for pre-emergence weed control.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	850 ± 140		11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Production of 2,4-DEP has been discontinued by the manufacturer (Berg 1982). It was developed for pre-emergence weed control, and its herbicidal activity may be due to a hydrolysis conversion to another herbicide, 2,4-D (Eto 1974). Toxicity data are only available for laboratory rats, and the acute oral LD50 indicates a moderate toxicity to that species. Toxicity data are not available for wildlife. The lack of production and low volume use estimates for this herbicide suggest a low potential exposure to wildlife.

Desmedipham

CAS #13684-56-5

Toxicity Class: V

Use Class: V

Chemical Name: Ethyl *m*-hydroxycarbanilate, carbanilate (ester)

Common and Trade Names: Betanex

Action: Herbicide

Properties: A colorless crystalline material, soluble in water at 7 mg/L. It is subject to hydrolysis under alkaline conditions.

Field Applications and Formulations: Desmedipham is a selective postemergence carbamate herbicide used to control a variety of annual weeds. It is sprayed in band or broadcast applications, and the major crop is sugar beets. Desmedipham is formulated as an emulsifiable concentrate (0.156 kg/L; 1.3 lb/gal).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	16	2,150[a]		12
Rat	U	U	tech	>10,250		12
	U	U	16	3,720		12

[a]Minimum lethal dose.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	16	2,025–10,250			12

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat, dog	U	U	16			90-day feeding study had a "no effect" level of >1,250 ppm in the diet	12
Northern bobwhite	U	U	16		2,480[a]		12

[a]4-day study.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Desmedipham is a selective herbicide used on sugar beets. It is absorbed by plant leaves and breaks down within several days following application (Beste 1983). Desmedipham is not readily leached from soils, and half-lives in most soils are less than 1 month (Beste 1983). Its predicted bioconcentration factor is low.

Desmedipham has low acute and subacute toxicity in laboratory mammals, and the dietary LC50 value for quail also indicates low subacute toxicity to that species. There have been no reports that desmedipham use has caused adverse effects in wildlife. Limited applications to sugar beets may tend to reduce wildlife exposure. Few toxicological data exist for wildlife species; however, it appears to have low toxicity to laboratory animals, brief environmental persistence, and limited field use.

Diallate

CAS #2303-16-4

Toxicity Class: III **Use Class:** V. Restricted

Chemical Name: *S*-(2,3-Dichloroallyl) diisopropylthiocarbamate

Common and Trade Names: Avadex, DATC

Action: Herbicide

Properties: An amber-colored liquid, miscible with organic solvents and soluble in water at 14 mg/L.

Field Applications and Formulations: Diallate is a pre-emergence selective carbamate herbicide used to control wild oats, millets, and other grasses. It is incorporated into the soil either pre- or postplanting. Diallate is applied to several crops; however, those receiving the major use include sugar beets, wheat, and edible beans. It is formulated as an emulsifiable concentrate (4EC) and in granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	U	510		12
Rat	U	U	U	395		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			"No effect" level of >600 mg/day	12
Rabbit	U	U	U	2,000–5,000			12
Rat	U	U	U			"No effect" level of >125 mg/day	12
Mallard	U	0.5	U		>5,000		12
Northern bobwhite	U	0.5	U		>5,000		12

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Diallate is a selective, soil-incorporated herbicide applied either aerially or from the ground. It has moderately low total field use relative to other carbamate herbicides. Microbial activity is the primary mechanism of degradation, and volatilization losses occur if not properly incorporated into the soil (Anderson and Domsch 1976). The half-life in soils is approximately 4 weeks (Anderson and Domsch 1976), and diallate is readily translocated and metabolized in plants (Food and Drug Administration 1982). Its bioconcentration factor, predicted from water solubility, is relatively low.

Diallate is of moderate acute oral toxicity in laboratory rats and dogs. Acute oral LD50's are not available for birds; however, dietary LC50's suggest very low subacute toxicities to mallards and quail (Beste 1983). Diallate has been determined to produce neurotoxic effects in hens, testicular and ovarian effects in dogs, and to induce tumor growth in mice (Food and Drug Administration 1982). It is not a widely used carbamate herbicide and has not been reported to cause adverse effects in wildlife populations. Toxicity data suggest moderate acute toxicity and potential adverse effects in animals chronically exposed. Moderately low field use, incorporation into the soil, and relatively short environmental persistence likely reduce diallate exposure to wildlife.

EPTC

CAS #759-94-4

Toxicity Class: IV **Use Class:** III

Chemical Name: *S*-Ethyl dipropylthiocarbamate

Common and Trade Names: Eptam, Eradicane (EPTC plus R-25788, an inert herbicide antidote)

Action: Herbicide

Properties: A liquid with an aromatic odor, EPTC is soluble in water at 365 mg/L (Hazardous Materials Advisory Committee and Consultants 1974).

Field Applications and Formulations: EPTC is a selective carbamate herbicide incorporated into the soil before planting or at weed germination. It is effective against annual grasses and broad-leaved weeds and is applied to several different crops. EPTC is sold in combination with R-25788 as Eradicane. Edible beans and peas receive the largest applications with secondary use on sugar beets, potatoes, and sunflowers. Eradicane is used primarily on corn. Formulations of these chemicals include emulsifiable concentrates (5 and 7EC) and granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	M	U	U	3,160		12
Rat	M	U	tech	1,630		11
	M	U	7E	1,325–1,500		11
	U	U	6.7E	2,000–2,870[a]		11
European starling	U	U	U	>100		225
Red-winged blackbird	U	U	U	100	(56–178)	225

[a]EPTC plus R-25788.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			90-day "no effect" level of 20 mg/day	12
Rabbit	U	U	U	10,000			12
Rat	U	U	U			90-day "no effect" level of 16 mg/day	12
Northern bobwhite	U	U	tech		20,000[a]		12

[a]7-day feed treatment.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: EPTC is a selective herbicide widely used alone or in formulation with R-25788, a herbicide antidote (safener), as Eradicane. It is readily absorbed by roots and translocated through the plant where it inhibits meristematic growth (Beste 1983). EPTC is usually applied to soil and is relatively nonpersistent (Beste 1983). Residue half-lives in moist loam soils are approximately 1 week; however, it is more persistent in dry soils (Fang et al. 1961). EPTC is rapidly volatilized from plant and soil surfaces and immediate incorporation into the soil prevents loss of the herbicide. The predicted bioconcentration factors for both EPTC and Eradicane are low. The principal mechanism of breakdown is microbial activity, and degradation products are not toxic (Food and Drug Administration 1982).

EPTC appears to be of low acute and subacute toxicity to most species tested. However, an acute oral LD50 of 100 mg/kg was determined for red-winged blackbirds (Schafer 1972), suggesting species differences. Oral, dermal, and dietary tests with mammals and birds generally indicate low toxicity, although EPTC has been demonstrated to inhibit cholinesterase activity. Data on its potential teratogenic, neurotoxic, reproductive, and mutagenic effects are not available. Despite its common field use on several different crops, there are no reports of adverse effects on wildlife resulting from EPTC use.

Ethephon

CAS #16672-87-0

Toxicity Class: IV **Use Class:** VI

Chemical Name: (2-Chloroethyl)phosphonic acid

Common and Trade Names: Cepha, Cerone, Ethrel, Flordimex, Florel, Gafgro

Action: Plant-growth regulator

Properties: A colorless solid very soluble in water, alcohol, and glycols and slightly soluble in aromatics.

Field Applications and Formulations: Ethephon is an organophosphorus plant-growth regulator. It is used to accelerate preharvest ripening of fruits and vegetables and as an end-of-season and postharvest treatment. Formulations include an emulsifiable concentrate (3.9%) and water soluble liquids (0.240 kg/L and 0.479 kg/L; 2 and 4 lb/gal).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	U	2,850		162
Rat	U	U	U	4,229		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U			2-year feeding trial with no effect up to 12,500 ppm in the diet	285
Mallard	U	U	U		>10,000[a]		285

[a]8-day LC50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Ethephon is an organophosphorus compound used to regulate plant-growth metabolism and growth at different stages of development (Eto 1974). Menzie (1980) discussed metabolism of this compound; however, little information is available on its environmental persistence. Its mechanism of action within the plant is thought to result from the release of ethylene into plant tissues (Eto 1974; Thomson 1982).

Ethephon is of low acute toxicity to laboratory mice and rats. Its potential subacute effects on reproduction, teratogenicity, and neurotoxicity have not been fully evaluated. Ethephon's subacute dietary toxicity to mallards is very low, and there have been no incidences of ethephon-related wildlife problems reported in the literature.

Glyphosate

CAS #1071-83-6

Toxicity Class: IV **Use Class:** III

Chemical Name: *N*-(Phosphonomethyl)glycine

Common and Trade Names: Kleenup, Roundup

Action: Herbicide

Properties: A white solid, soluble in water at 12,000 mg/L and insoluble in other solvents.

Field Applications and Formulations: Glyphosate is an organophosphorus herbicide used to control many species of both annual and perennial plants including grasses, broad-leaved weeds, and woody plants. It is applied prior to the emergence of crops or as a spot treatment within stands. The major-use agricultural crop is cotton with some use on pasture, corn, and sorghum. Glyphosate is also commonly used to control weeds along right-of-ways, in forests, and on industrial or recreational sites. It is formulated as the aqueous solution of the isopropylamine salt (Berg 1982).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	tech	4,300		11
	U	U	tech	5,600		12
	U	U	formulation	4,900		11
	U	U	formulation	5,400		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	>7,940			285
Dog, Rat	U	U	tech			Dietary levels of 200, 600, and 2,000 ppm over 90 days did not have any observed effects	12
Dog, Rat	U	U	tech			2-year feeding study with dietary levels of 30, 100, and 300 ppm had no adverse effects	12
Japanese quail	U	0.5	41		>5,000	No overt signs of toxicity to 5,000 ppm	122

Effects of Field Applications and Field Tests on Wildlife: Mule deer food selection and consumption was measured under simulated field conditions using untreated browse and browse treated at a 2.3 kg/ha (2 lb/acre) equivalent rate. Browse treated with glyphosate did not affect consumption, and when given the choice between treated and untreated browse, deer showed no preference or ate more of the treated foliage (Sullivan and Sullivan 1979).

Persistence and Hazard Evaluation: Glyphosate is a nonselective postemergence herbicide widely used for both agricultural and nonagricultural control of vegetation. Glyphosate is absorbed by foliage and translocated throughout the plant. Decomposition of glyphosate in soil and water is through microbiological degradation and occurs rapidly (Rueppel et al. 1977; Weed Science Society of America 1979). Half-lives in natural water systems range from 7 to 10 weeks and in soils from about 3 to 19 weeks, depending on the number of microbes in the system (Ghassemi et al. 1981). Glyphosate is highly soluble in water and has a low predicted bioconcentration factor. Animal feeding studies have confirmed this low bioconcentration potential (Ghassemi et al. 1981).

The toxicity of glyphosate, and the formulated isopropylamine salt of glyphosate, is low for both mammal and bird species that have been tested. There have been no reported wildlife problems associated with the use of this herbicide. Although glyphosate is an organic phosphorphorus compound containing a phosphorous-oxygen double bond, the R-group configuration at the phosphorous site does not allow this compound to be readily grouped in any of the general subclasses of organophosphate pesticides. Therefore, it is not considered to be a typical organophosphorus pesticide and has not been reported to have anticholinesterase activity.

Molinate

CAS #2212-67-1

Toxicity Class: III **Use Class:** III

Chemical Name: *S*-Ethyl hexahydro-1*H*-azepine-1-carbothioate

Common and Trade Names: Ordram

Action: Herbicide

Properties: A clear liquid with an aromatic odor, molinate is stable to hydrolysis, soluble in water at 800 mg/L, and miscible in most organic solvents.

Field Applications and Formulations: Molinate is a selective carbamate herbicide used to control grassy and broad-leaved weeds, and particularly watergrass (*Echinochloa* spp.) in rice. It is applied preplant and postemergence in rice, the only major-use crop. Molinate is formulated in an emulsifiable concentrate (8EC) and in granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	M	U	tech	795		12
	M	U	6E	1,260		12
Rat	M	U	tech	720		12
	M	U	6E	584–794		12
	U	U	tech	549–955		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			90-day dietary "no effect" level of 20 mg/kg per day	12
Rabbit	U	U	6E	>10,000			12
Rat	U	U	U			90-day dietary "no effect" level of 8 mg/kg per day	12
Japanese quail	U	0.5	99		>5,000		122
Mallard duckling	U	I	6E		>13,000[a]		12

[a]5-day feed treatment.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Molinate is a selective herbicide rapidly absorbed by plant roots and translocated to the leaves. It is used on rice and applied to soil prior to flooding, or to water after flooding. Half-lives for molinate in moist loam soils are about 3 weeks, and microbial action is the primary mechanism of degradation. Molinate has a low bioconcentration potential.

Molinate is of moderate to slight acute toxicity in mammals. The dietary LC50 for mallard ducklings indicates low subacute toxicity to that species. Information on possible neurotoxic, mutagenic, and teratogenic effects are not available. Molinate has moderately high field use on rice, a crop that tends to attract birds. The published literature does not contain reports of molinate applications causing adverse effects in wildlife, and it has been reported to be harmless to wildlife (Thomson 1982).

Pebulate

CAS #1114-71-2

Toxicity Class: III **Use Class:** V

Chemical Name: *S*-Propyl butylethylthiocarbamate

Common and Trade Names: PEBC, Tillam

Action: Herbicide

Properties: A clear liquid with an aromatic odor, soluble in water at 60 mg/L.

Field Applications and Formulations: Pebulate is a preplant selective carbamate herbicide, incorporated into the soil to control grassy and broad-leaved weeds. Principal agricultural applications are made on tobacco and tomatoes. Pebulate is formulated as an emulsifiable concentrate (6EC) and in granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	M	U	U	1,652		12
Rat	M	U	U	921–1,120		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			90-day dietary "no effect" level of 20 mg/kg per day	12
Rabbit	U	U	tech	>4,640			11
Rat	U	U	U			90-day dietary "no effect" level of 16 mg/kg per day	12
Northern bobwhite	U	U	U		8,400[a]		285

[a]7-day dietary LC50 study.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Pebulate is a selective herbicide incorporated into the soil by mechanical methods or through overhead irrigation. It is absorbed by the roots and translocated through the plant where it is rapidly metabolized (Beste 1983). Pebulate is nonpersistent in soils, with a half-life of about 2 weeks (Beste 1983). Its bioconcentration factor, predicted from water solubility, is low.

Pebulate has slight acute oral and dermal toxicity to laboratory mammals. Its subacute dietary toxicity to northern bobwhites is also low (Worthing 1979). Pebulate has a moderate to low total field use, and it has not been associated with adverse effects on wildlife. Substantial data gaps exist for acute and chronic effects on wildlife species.

Phenmedipham

CAS #13684-63-4

Toxicity Class: V

Use Class: V

Chemical Name: Methyl *m*-hydroxycarbanilate, *m*-methylcarbanilate

Common and Trade Names: Betanal

Action: Herbicide

Properties: Colorless crystals, soluble in polar organic solvents and in water at 3 mg/L.

Field Applications and Formulations: Phenmedipham is a selective carbamate herbicide used on sugar beets. It is applied as a postemergence spray, or as a band or broadcast treatment to control annual weeds. Phenmedipham is formulated as an emulsifiable concentrate (1.3EC).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	U	U	tech	>4,000		12
Guinea pig	U	U	tech	>4,000		12
Mouse	U	U	tech	>8,000		12
Rat	U	U	tech	>8,000		12
	U	U	15.9	>2,000		12
Chicken	U	U	tech	>3,000		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			2-year feeding study with no compound-related effects at 1,000 ppm or less	12
Rabbit	U	U	15.9	>10,000			12
Rat	U	U	tech	>4,000			12
	U	U	U			120-day feeding study at 125, 250, and 500 mg AI/kg per day showed food intake to be inversely related to dose	285

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluations: Phenmedipham is used on sugar beets as a selective herbicide and has a moderately low total field use. It is applied as a postemergence spray and is degraded in plants within several days (Beste 1983). Half-lives in slightly acidic soils are 28 to 55 days (Kossmann 1970). The predicted bioconcentration potential of phenmedipham is moderately low.

Phenmedipham has low acute oral and dermal toxicity to laboratory species tested. Dietary studies using dogs and rats also indicate a low chronic oral toxicity for this herbicide; however, it is reported to be toxic to fish (Thomson 1982). A 2-year oncogenicity study at dietary levels up to 500 ppm showed no compound-related histomorphologic effects in rats (Beste 1983). Low toxicity, field use, and persistence suggest a relatively low hazard to wildlife.

Phosfon

CAS #115-78-6

Toxicity Class: II **Use Class:** Not applicable

Chemical Name: Tributyl(2,4-dichlorobenzyl)phosphonium chloride

Common and Trade Names: Chlorfonium, Chlorphonium, Phosphon

Action: Plant-growth regulator

Properties: Colorless crystals, readily soluble in water.

Field Applications and Formulations: Phosfon is an organophosphorus plant regulator used in greenhouses and gardens as a height retardant for ornamentals. It does not have agricultural crop applications and formulations include dusts (1 and 10%) and liquid (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	178		11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: The production of phosfon has been discontinued by the manufacturer (Berg 1982). Phosfon is a plant-growth regulator with specific use as a height retardant for chrysanthemums, Easter lilies, and other ornamentals. There is a paucity of toxicity information for this compound. Because the major use of this chemical consists of greenhouse applications, the potential for wildlife exposure is likely low.

Propham

CAS #122-42-9

Toxicity Class: IV **Use Class:** VI

Chemical Name: Isopropyl carbanilate

Common and Trade Names: Ban-Hoe, Beet-Kleen, Chem-Hoe, IFC, INPC, IPC, IPC-400, IPPC, Premalox, Triherbide, Tuberite

Action: Herbicide

Properties: White crystals, soluble in most organic solvents and in water at 250 mg/L.

Field Applications and Formulations: Propham is a selective carbamate herbicide applied preplant, pre-emergence, and postemergence to control many annual grasses and some broad-leaved weeds. It is absorbed by plant roots where it exerts its herbicidal activity (Beste 1983), and it is often formulated with other herbicides. Formulations include an emulsifiable concentrate (0.240 kg/L; 2 lb/gal), flowable (0.360–0.479 kg/L; 3–4 lb/gal), granules (15%), and wettable powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	tech	3,000		12
Rat	U	U	tech	9,000		12
	U	U	0.479 kg/L (4 lb/gal)	10,000		12
	U	U	15G	7,600		12
	U	U	tech	5,000		11
Mallard	M	3	40	>2,000		264

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog (beagle)	U	U	U			90-day dietary "no effect" level of 2,000 ppm in the diet	12
Rabbit	U	U	0.45 kg/L (4 lb/gal)	10,200			12
Rat, mouse, hamster	U	U	U			18- to 33-month feeding trials at levels from 1,000 to 20,000 ppm in the diet did not produce tumors or ill effects	12

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Propham is a relatively minor-use carbamate herbicide applied using both ground and air techniques. Its herbicidal action depends primarily on uptake by roots, and it is generally incorporated into the soil at the weed-root zone by rainfall or irrigation (Beste 1983). Degradation in soil is mainly by microorganisms, and its half-life, of about 15 days, may vary widely with microbe activity and soil moisture (Beste 1983). At temperatures above 21°C (70°F), propham rapidly decomposes (Thomson 1982). Its predicted bioconcentration potential is low. Propham has low acute and subacute toxicity to birds and mammals. Extremely high dietary levels have not produced adverse effects in test animals, and the oncogenic potential of propham is also low.

Thiobencarb

CAS #28249-77-6

Toxicity Class: III **Use Class:** V

Chemical Name: *S*-(*p*-Chlorobenzyl) diethylthiocarbamate

Common and Trade Names: Benthiocarb, Bolero, Saturn, Saturno

Action: Herbicide

Properties: A yellow to brown liquid, soluble in alcohols, xylene, acetone, and in water at 30 mg/L.

Field Applications and Formulations: Thiobencarb is selective carbamate herbicide applied pre-emergence to early postemergence to control several species of weeds in rice. It is formulated as emulsifiable concentrates (50%; 4 and 8EC) and granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	U	U	tech	2,745		12
	U	U	8EC	560		12
Rat	U	U	tech	920–1,903		12
	U	U	8EC	1,036–2,810		12
Mallard	U	U	tech	>10,000		12
Northern bobwhite	U	U	tech	>7,800		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	tech			2-year chronic oral "no effect" level of 30 ppm	12
	U	U	tech			90-day "no effect" level of 660 ppm	12
Rabbit	U	U	tech			No teratogenic effects at an unspecified dosage	12
Rat	U	U	tech			90-day subacute "no effect" level of 660 ppm	12
Mallard	U	U	tech		>5,000[a]		12
Northern bobwhite	U	U	tech		>5,000[a]		12

[a]8-day subacute oral test.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Thiobencarb is a selective herbicide applied to rice and has a moderately low total field use. Degradation is principally through microbial activity, with some volatilization and photodecomposition (Beste 1983). Half-lives in soils range from 2 to 3 weeks under aerobic conditions (Beste 1983), and its activity may persist for about 30–40 days (Thomson 1982). The predicted bioconcentration potential for thiobencarb is relatively low, and studies of aquatic organisms have confirmed its low bioconcentration (Sanders and Hunn 1982).

Thiobencarb has low acute oral toxicity for the species tested. Information available indicates no oncogenic, mutagenic, or teratogenic effects in the species tested (Beste 1983). Adverse reproductive effects in a threegeneration rat study were not observed at a dietary level of 250 ppm (Beste 1983). Applications of thiobencarb have not been reported to harm wildlife, and studies have demonstrated a low environmental hazard to freshwater organisms (Sanders and Hunn 1982).

Triallate

CAS #2303-17-5

Toxicity Class: IV

Use Class: III

Chemical Name: *S*-(2,3,3-Trichloroallyl) diisopropylthiocarbamate

Common and Trade Names: Avadex-BW, Far-Go

Action: Herbicide

Properties: An oily liquid, soluble in water at 4 mg/L and in most organic solvents.

Field Applications and Formulations: Triallate is a selective pre-emergence carbamate herbicide used to control wild oats in several types of cereal crops and peas. The majority of triallate use is on wheat. It is incorporated into the soil, immediately upon application, to a depth of 5 cm (2 in.). Triallate is formulated as an emulsifiable concentrate (4EC) and in granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	1,675–2,165		11
Northern bobwhite	U	U	tech	>2,251		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			Oral dosages up to 20,000 mg/kg caused no symptoms	285
Rabbit	U	U	tech	8,200			12
	U	U	4EC	2,000–20,000			12
	U	U	10G	>20,000			12
Mallard	U	U	tech		>5,000[a]		12
Northern bobwhite	U	U	tech		>5,000[a]		12

[a]8-day dietary LD50.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Triallate is a selective herbicide used on wheat and barley. Its degradation in soils is primarily a result of microbial action (Food and Drug Administration 1982; Beste 1983). The half-life in soil is 120 days, and losses due to volatilization are significant. The overall environmental persistence of triallate is moderate to low, and its predicted bioconcentration factor is also low.

Triallate is of moderate to very low acute and subacute toxicity to birds and mammals. Acute oral dosages of up to 20 g/kg produced no overt symptoms in dogs (Worthing 1979). Data on teratogenic and reproductive effects are not available; however, it was not carcinogenic in rats at levels up to 200 ppm (Beste 1983). Substantial acreages of wheat are treated each year with triallate; however, adverse effects on wildlife resulting from its use have not been reported in the literature.

Vernolate

CAS #1929-77-7

Toxicity Class: IV **Use Class:** III

Chemical Name: *S*-Propyl dipropylthiocarbamate

Common and Trade Names: Surpass, Vernam

Action: Herbicide

Properties: A clear liquid, miscible with most organic solvents and in water at 107 mg/L.

Field Applications and Formulations: Vernolate is a selective carbamate herbicide that is incorporated into the soil to control a broad range of broad-leaved and grassy weeds. The two major use crops are soybeans and peanuts. It is applied both preplant and pre-emergence and is formulated as emulsifiable concentrates (6 and 7EC) and in granules (10%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	1,780		12
	M	U	6E	1,800		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			90-day dietary "no effect" level of 38 mg/kg per day	12
Guinea pig	U	U	tech	4,640			12
	U	U	6E	10,000			12
Rat	U	U	U			90-day dietary "no effect" level of 32 mg/kg per day	12
Northern bobwhite	U	U	tech		12,000[a]		12
	U	U	6E		14,500[a]		12

[a]7-day dietary LC50 test.

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Vernolate is a selective herbicide applied by incorporation into the soil and is rapidly absorbed by plant roots and readily translocated. Microbial breakdown is the primary degradation mechanism in soils, and if not incorporated into the soil, volatilization occurs rapidly (Food and Drug Administration 1982). Vernolate does not persist in soils when applied at recommended rates, and the half-life in moist loam is about 1.5 weeks (Beste 1983). Residues in plants have half-lives of about 2–3 weeks (Food and Drug Administration 1982). The bioconcentration potential of vernolate, predicted from water solubility, is low.

The acute oral and dermal toxicity for vernolate ranges from moderate to nontoxic in species tested. Acute toxicity data for wildlife are not available. Dietary LC50's for northern bobwhite quail indicate subacute exposure to be practically nontoxic in this species. Information on the potential reproductive, mutagenic, and teratogenic effects on vernolate are not available; however, vernolate does not produce delayed neurotoxic effects in hens (Food and Drug Administration 1982). There are no toxicologically important metabolites of vernolate (Food and Drug Administration 1982), and there have been no reports of its use resulting in adverse effects on wildlife. Vernolate has moderately high field use, appears to have relatively low acute and subacute toxicity, and is relatively nonpersistent.

Fungicides

Benomyl

CAS #17804-35-2

Toxicity Class: V **Use Class:** III

Chemical Name: Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate

Common and Trade Names: Arboral, Benlate, Correx, Elmosan, Grex, Lignasan, Tersan-1991, Ultra-Sofril

Action: Fungicide

Properties: A white crystalline solid, soluble in water at 3.8 mg/L.

Field Applications and Formulations: Benomyl is a systemic, foliar carbamate fungicide used to control a broad spectrum of fungi on nuts, fruits, vegetables, turf, and field crops. Major crops include rice, peanuts, and pecans. It is formulated as oil dispersible (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	>10,000		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	>10,000			11
Japanese quail	U	0.5	50		>5,000	No overt signs of toxicity to 5,000 ppm	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Benomyl is a fungicide applied to crops, ornamentals, and turf to control many different diseases. Applied to turf and bare soil in a 50WP formulation at 2.3 and 5.7 kg/ha (2 and 5 lb/acre), residue half-lives were 3–6 months on turf and 6–12 months on bare soil (Baude et al. 1974). Breakdown products include 2-AB, isocyanate, an unidentified irreversible ChE inhibitor, and MBC, which has no anticholinesterase activity (Krupka 1974; Food and Drug Administration 1982). Benomyl and its metabolites do not accumulate in animal tissues (Gardiner et al. 1974), and its predicted bioconcentration factor is low.

The acute toxicity of benomyl is very low for laboratory rats. Acute and subacute toxicity data for wildlife species are not available. Some studies using rats have not found reproductive, teratogenic, or mutagenic effects at various levels tested (Sherman et al. 1975). However, fetotoxic and teratogenic effects were reported for rats and mice in another study (Kavlock et al. 1982), and benomyl may possibly affect the mammalian gonad (Office of Pesticide Programs 1979). Benomyl has been found to reduce earthworm numbers (Stringer and Lyons 1977). Its use has not been associated with any adverse effects on wildlife populations.

Ferbam

CAS #14484-64-1

Toxicity Class: IV **Use Class:** V

Chemical Name: Tris(dimethyldithiocarbamato)iron

Common and Trade Names: Carbamate, Ferbamate, Ferbame, Ferberk, Fermocide, Hexaferb, Knockmate, Niacide, Sup'r-Flo Ferbam Flowable, Trifungol, Vancide

Action: Fungicide

Properties: A black powder, soluble in most organic solvents and in water at 130 mg/L. It is compatible with other nonalkaline pesticides.

Field Applications and Formulations: Ferbam is a carbamate foliar fungicide used on apples, grapes, cherries, peaches, and many other crops. It is used to control apple scab, cedar apple rust, and is widely used as a protective fungicide. Ferbam is formulated in dust (0.6–25%) and wettable powders (3–98%; Thomson 1982).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	>4,000		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			2-year chronic oral "no effect" level of 5 mg/kg per day	285
Rat	U	U	U			2-year chronic oral "no effect" level of 250 ppm in the diet	285

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Ferbam is a ferric dithiocarbamate used as a foliar fungicide on several fruit crops. There is a paucity of information concerning the environmental fate and persistence of ferbam. It is not stored in body tissues (Worthing 1979), and its bioconcentration, predicted from water solubility, is low.

Information on ferbam's acute and chronic toxicity to wildlife is not available. Acute oral toxicity test results and reproductive studies with rats indicate low toxicity to this species.

Mancozeb

CAS #8018-01-7

Toxicity Class: V **Use Class:** III

Chemical Name: [Ethylenebis[dithiocarbamato]]manganese, mixture with [ethylenebis[dithiocarbamato]]zinc

Common and Trade Names: Dithane M-45, Fore, Mancofol, Manzeb, Manzin, Nemispor, Polycar, Ziman-Dithane

Action: Fungicide

Properties: A grey-yellow powder soluble in most organic solvents and nearly insoluble in water.

Field Applications and Formulations: Mancozeb is a protective carbamate foliar fungicide used to control a wide range of foliar diseases. It is applied to agricultural crops, with the major use on potatoes. Mancozeb is often combined with other pesticides and is formulated as dust (4.8–15%), liquid flowable (0.455 kg/L; 3.8 lb/gal), and wettable powder (80%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	>8,000		11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Mancozeb is an ethylene bisdithiocarbamate fungicide closely related to, but chemically different from, maneb and zineb. It is widely used as a protective foliar fungicide and has improved stability over earlier maneb formulations (Von Rumker et al. 1974). Like maneb, ethylene thiourea (ETU) is one of the many metabolites of mancozeb (Food and Drug Administration 1982). There is little information on the environmental persistence of mancozeb; however, it is rapidly excreted by animals and seems to have a low bioaccumulation potential (Food and Drug Administration 1982).

Few data are available for evaluating the acute and subacute toxicity of mancozeb. The acute oral rat LD50, greater than 8,000 mg/kg, suggests mancozeb to be relatively nontoxic to that species. Data are not available to evaluate its avian toxicity. A common metabolite of the ethylene bisdithiocarbamates, ethylene thiourea (ETU), has been demonstrated to have potential antithyroid, carcinogenic, and teratogenic effects (Von Rumker et al. 1974; Food and Drug Administration 1982). Incidences of mancozeb applications resulting in adverse effects to wildlife have not been reported in the literature, and on an acute basis, mancozeb appears to have low toxicity. Chronicity tests have not been done to evaluate possible adverse effects caused by the parent compound or its metabolites, especially ETU.

Maneb

CAS #12427-38-2

Toxicity Class: V **Use Class:** III

Chemical Name: [Ethylenebis[dithiocarbamato]]manganese

Common and Trade Names: Dithane M-22, Griffin Manex, Kypman, Lonocol M, M-45, Maneba, Manebgam, Manesan, Manex, Manzate, Manzati, Manzeb, Manzin, M-Diphar, Nespor, Polyram-M, Remasan, Tersan-LSR, Trimangol, Tubothane, Unicrop Maneb, Vancide

Action: Fungicide

Properties: A yellow crystalline solid, insoluble in most organic solvents and slightly soluble in water.

Field Applications and Formulations: Maneb is a carbamate foliar fungicide that is also applied as a seed treatment. It is used to control blights and other diseases on crops and turf. The major agricultural crop is potatoes; however, tomatoes, sweet corn, and edible beans and peas also receive substantial treatments. It is used in combination with several other pesticides and is formulated in dust (1 to 20%), flowable (0.479 kg/L; 4 lb/gal), paste (3.2%), and wettable powders (70 and 80%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	6,750		11

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Dog	U	U	U			1-year chronic oral "no effect" level of 80 ppm in the diet	285
Rat	U	U	U			2-year chronic oral "no effect" level of 250 ppm in the diet	285
Japanese	U	0.5	80		>5,000		122
quail	U	U	80% + 16% zinc		>5,000		122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Maneb is one of the ethylene bisdithiocarbamate fungicides, closely related to mancozeb and zineb, but having distinctive chemical and biological properties (Berg 1982). Little information is available concerning the environmental fate and persistence of maneb. Based on studies done in rats and cattle, the bioaccumulation potential of maneb seems relatively low (Food and Drug Administration 1982).

Acute and subacute toxicity data for maneb have not been evaluated for wildlife species. Chronic feeding studies on dogs and rats, and the acute oral LD50 for rats, indicate low toxicity for this fungicide. Maneb has been reported to be toxic to fish (Von Rumker et al. 1974). Chronic toxicity tests indicate a mutagenic and oncogenic (tumor-inducing) potential for maneb (Food and Drug Administration 1982), and chronic oral exposure of mice to maneb increased the incidence of benign lung tumors (Food and Drug Administration 1982). Ethylene thiourea (ETU), a metabolite of maneb, has potential carcinogenic, antithyroid, and teratogenic effects (Von Rumker et al. 1974; Food and Drug Administration 1982).

Metham

CAS #144-54-7

Toxicity Class: III **Use Class:** VI

Chemical Name: Methyldithiocarbamic acid

Common and Trade Names: Carbam, Karbation, Maposol, Metam, Metam-Fluid, Metam-Sodium (monosodium salt), Sistan, Solasan, Sometam, Trimaton, Vapam

Action: Fungicide, nematicide, herbicide

Properties: A white crystalline solid, insoluble in most organic solvents and soluble in water at 722,000 mg/L.

Field Applications and Formulations: Metham is a carbamate soil fungicide, nematicide, and herbicide with fumigant action. Metham is used as a general soil fumigant with principal agricultural applications made to potatoes. It is formulated as an aqueous solution (32.7%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Mouse	M	U	U	285		12
Rat	M	U	U	820		12

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rabbit	U	U	U	2,000			12
Japanese quail	U	0.25	tech		>5,000	14% mortality at 5,000 ppm	124
Mallard	U	0.30	tech		>5,000	No mortality to 5,000 ppm	124
Northern bobwhite	U	0.50	tech		>5,000	No mortality to 5,000 ppm	124
Ring-necked pheasant	U	0.30	tech		>5,000	No mortality to 5,000 ppm	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Metham is a herbicide and fungicide applied to the soil that is also effective against nematodes. The majority of its limited field use is on potatoes. Metham is absorbed by roots, is translocated through the plant, and generally degrades in soils within 5 h (Beste 1983). It is broken down primarily by chemical means (Beste 1983) and has an extremely low predicted bioconcentration factor.

Metham is of moderate to low acute toxicity to mammals and of low subacute toxicity to birds. Information on its neurotoxic, teratogenic, and reproductive effects is unavailable. In general, metham appears to have low apparent acute and subacute toxicity, extremely short environmental persistence, and very low total field use.

Metiram

CAS #9006-42-2

Toxicity Class: V **Use Class:** V

Chemical Name: Metiram

Common and Trade Names: Carbatene, PETD, Polyram, Polyram-Combi, Zinc metiram

Action: Fungicide

Properties: A light-yellow solid, soluble in water at 10,000 mg/L. It is a mixture of a dithiocarbamate and zinc.

Field Applications and Formulations: Metiram is a broad-spectrum foliar carbamate fungicide used to control diseases on top fruits, field crops, and vegetables. The two major agricultural crops are apples and potatoes. Metiram may also suppress some species of mites (Thomson 1982). It is formulated in dust (7%) and wettable powder (80%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	>10,000		11

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Metiram is an ethylene bisdithiocarbamate (EBDC) used to control a broad spectrum of fungi. The environmental fate and persistence of metiram is largely unknown. It has been reported to have a relatively long residual life (Thomson 1982), and its predicted bioconcentration factor is low.

There are few toxicity data available for metiram. The acute oral rat LD50 indicates a low toxicity to that species; however, acute and subacute toxicity data for wildlife species are not available. Ethylene thiourea, a degradation product of the EBDC's, has been determined to have antithyroid, teratogenic, oncogenic, and carcinogenic potential (Food and Drug Administration 1982). There have been no reported effects on wildlife resulting from the use of metiram.

Nabam

CAS #142-59-6

Toxicity Class: III **Use Class:** VI

Chemical Name: Disodium ethylenebis[dithiocarbamate]

Common and Trade Names: Chem Bam, Dithane, DSE, Nabame, Nabasan, Parzate, Spring-Bak

Action: Fungicide

Properties: Colorless crystals, soluble in water at 200,000 mg/L, forming a yellow solution.

Field Applications and Formulations: Nabam is a phytotoxic dithiocarbamate fungicide that has been largely superseded by zineb (Worthing 1979). It is used to make other carbamate fungicides by combining it with manganese or zinc salts (Thomson 1982). It is also applied to soil with some apparent systemic activity (Worthing 1979). Formulations include liquid solutions (9.5, 18, 19, and 22%) and soluble powders (85 and 93%; Thomson 1982).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Domestic goat	M	11	93	>800		131
Rat	U	U	U	395		285
Japanese quail	M	2	93	2,120	(1,680–2,670)	131
Mallard	M	3–4	93	>2,560		131
Ring-necked pheasant	M	3–5	93	707	(500–1,000)	131
Rock dove	M/F	U	93	>2,000		131
Bullfrog	F	U	93	420	(250–707)[a]	131

[a]Range from the highest dosage producing no mortality to the lowest dosage producing 100% mortality.

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Japanese quail	U	0.5	93		>5,000	No overt signs of toxicity to 5,000 ppm	122
Mallard	U	0.3	93		>5,000	No mortality to 5,000 ppm	124
Northern bobwhite	U	0.5	93		>5,000	11% mortality at 5,000 ppm	124
Ring-necked pheasant	U	0.3	93		>5,000	No mortality to 5,000 ppm	124

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Nabam is a dithiocarbamate fungicide that has current negligible field use. It is used to make other fungicides including maneb and zineb, and when used alone, is phytotoxic (Thomson 1982). Its predicted bioconcentration factor is low.

Nabam has moderate to slight acute oral toxicity to laboratory mammals and wild bird species, and its subacute dietary toxicity to birds is low (Hill et al. 1975). Like other ethylene bisdithiocarbamates, it is relatively unstable and degradation products include ethylene thiourea (ETU) and other compounds (Menzie 1974). ETU is of toxicological concern as it has been shown to be carcinogenic, teratogenic, oncogenic (induces tumors), and has antithyroid activity (Food and Drug Administration 1982). Field use of nabam has not been reported to cause adverse effects in wildlife species, and its low current field use suggests low exposure to wildlife.

Thiophanate

CAS #23564-06-9

Toxicity Class: V **Use Class:** VI

Chemical Name: Diethyl 4,4′-*o*-phenylenebis[3-thioallophanate]

Common and Trade Names: Cerobin, Enovit, Pelt Sol, Topsin, Topsin-E

Action: Fungicide

Properties: A colorless crystalline solid, insoluble in water.

Field Applications and Formulations: Thiophanate is a broad-spectrum, systemic carbamate fungicide used to control diseases on turf and is used on some agricultural crops outside the United States (Thomson 1982). It is formulated as a flowable and a wettable powder (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Guinea pig	U	U	U	>10,000		285
Mouse	U	U	U	>10,000		285
Rabbit	U	U	U	>10,000		285
Rat	U	U	U	>10,000		285

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Guinea pig	U	U	U	>10,000			285
Mouse	U	U	U	>10,000			285
Rabbit	U	U	U	>10,000			285
Rat	U	U	U	>10,000			285

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Thiophanate is a systemic fungicide with current negligible field use in the United States. It is currently under development, and field applications may increase (Thomson 1982). It is applied as a foliar spray, seed treatment, a soil drench, and a fruit dip to control a broad spectrum of diseases (Thomson 1982). Few data are available concerning its environmental fate and persistence.

Thiophanate is relatively nontoxic to mammals by acute oral and dermal exposure. Avian toxicity data, both acute and chronic, are lacking in the published literature. Thiophanate is not as widely used as its methyl homolog, thiophanate-methyl (Worthing 1979). The compound has low mammalian toxicity, extremely limited current use in the United States, and reports of wildlife effects are lacking in the literature.

Thiophanate-methyl

CAS #23564-05-8

Toxicity Class: V **Use Class:** VI

Chemical Name: Dimethyl 4,4′-*o*-phenylenebis[3-thioallophanate]

Common and Trade Names: Cercobin Methyl, Cycosin, Dinonsan, Duosan, Easout, Enovit-Super, Fungitox, Fungo, Labilite, Mildothane, Pelt-44, Sigma, Topsin-M, Trevin

Action: Fungicide

Properties: A colorless crystalline solid that is sparingly soluble in most organic solvents and slightly soluble in water.

Field Applications and Formulations: Thiophanate-methyl is a broad-spectrum carbamate fungicide with a curative and preventative activity. It is used on turf and agricultural crops to control a broad range of fungal pathogens. Thiophanate-methyl is formulated as a flowable (50%), paste (3%), wettable powder (50 and 70%), and in ULV (50%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Dog	M	U	tech	4,000		114
	F	U	tech	4,000		114
Guinea pig	M	U	tech	3,640	(3,050–4,040)	114
	F	U	tech	6,700	(5,770–7,770)	114
Mouse	M	U	tech	3,510	(3,140–3,930)	114
	F	U	tech	3,400	(3,100–3,780)	114
Rabbit	M	A	tech	2,270	(1,890–2,720)	114
	F	A	tech	2,500	(1,980–3,150)	114

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	U	tech	7,500	(6,550–8,470)	114
	F	U	tech	6,640	(5,980–7,360)	114
Japanese quail	M	U	tech	>5,000		114
	F	U	tech	>5,000		114

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Guinea pig	M/F	U	tech	>10,000			114
Mouse	M/F	U	tech	>10,000			114
Rabbit	M/F	A	tech	>10,000			114
Rat	M/F	U	tech	>10,000			114

Effects of Field Applications annd Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Thiophanate-methyl is a broad-spectrum fungicide with low agricultural use in the United States. It is used outside of the United States on many types of crops (Thomson 1982). In plants, it is degraded to carbendazin and other metabolites, the major one being methyl benzimidazole carbamate.

Thiophanate-methyl is of low acute oral and dermal toxicity. Chronic effects have only been demonstrated at extremely high dietary levels. It has low potential to affect reproduction, as well as a low mutagenic and carcinogenic potential (Vettorazzi 1976). Data on its environmental fate and toxicity of its metabolites are lacking.

Thiram

CAS #137-26-8

Toxicity Class: III **Use Class:** VI

Chemical Name: Bis(dimethylthiocarbamoyl) disulfide

Common and Trade Names: AAtack, Arasan, Aules, Chipco Thiram, Cunitex, Evershield, Fermide, Fernasan, Flo Pro, Hexathir, Mercuram, Nomersam, Polyram-Ultra, Pomarsol forte, Spotrete, T Seed Protectant, Tersan, Tetrapom, Thimer, Thioknock, Thiotex, Thiramad, Thirasan, Thiuramin, Thylate, Tirampa, Trametan, Tripomol, Tuads, Vancide

Action: Fungicide, animal repellent, seed protectant

Properties: Colorless crystals, soluble in water at 30 mg/L.

Field Applications and Formulations: Thiram is an agricultural carbamate fungicide applied to several types of crops and on turf. It is used to repel rabbits, deer, birds, mice, and other animals for the protection of fruit trees, ornamentals, and nursery stock. Thiram is also used as a seed protectant against blight and decay. The major agricultural use is on apples. Thiram is formulated as dust, flowable (0.210, 0.348, and 0.479 kg/L; 1.75, 2.9, and 4 lb/gal), and wettable powder. It is also used in combination with other pesticides.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	780		11
Mallard	F	3	99+	>2,800		131
Ring-necked pheasant	M	3–4	99+	673	(485–932)	131

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Japanese quail	U	0.5	95		>5,000	No mortality to 5,000 ppm	122
Mallard	U	0.3	95		>5,000	22% mortality at 5,000 ppm	124
Northern bobwhite	U	0.5	95		3,950		124
Red-legged partridge	F	A	tech			Nine pairs of birds fed 100 mg/kg for 3 weeks had a 30% decrease in egg production and 60% decrease in hatchability	97
Ring-necked pheasant	U	0.3	95		>5,000	No mortality at 5,000	124

Effects of Field Applications and Field Tests on Wildlife: Penned northern bobwhites, wild turkeys, and gray squirrels were offered seeds treated with thiram and endrin in combination and untreated seeds. Treated seeds were also available to a wild population of cotton rats. It was concluded that small birds and rodents could be adversely affected by eating treated seeds and that its repellent activity was learned through tasting and rejecting seeds. The lethal oral dose for quail was one seed (Hamrick 1967). The effects of endrin and thiram were not separated, and it is likely that the principal toxic agent was endrin rather than thiram.

Persistence and Hazard Evaluation: Thiram is an agricultural fungicide, also used as an animal repellent. It is applied to twigs of nursery stock, sprouts, roots, and seeds. It is also used to control several diseases and to repel deer, rabbits, and small rodents. A relatively low number of acres are treated each year for fungus control. It is easily degraded in the soil by microbial activity (Radwan 1969), but few other data on its environmental fate and persistence are available. The bioconcentration factor for thiram, predicted from water solubility, is low.

Thiram has a moderate to low acute oral toxicity to mammals and birds. Subacute dietary studies with birds also indicate low toxicity. Large daily dietary doses have been shown to adversely impact reproduction in rats and partridges. There have been no reports of thiram applications alone resulting in wildlife mortality or adverse effects. Thiram has low total field use and relatively low acute and subacute toxicity to mammals and birds. Information concerning its environmental fate and persistence as well as its other potential chronic effects are lacking.

Zineb

CAS #12122-67-7

Toxicity Class: V **Use Class:** V

Chemical Name: [Ethylenebis[dithiocarbamato]]zinc

Common and Trade Names: Aspor, Chem Zineb, Crystal Zineb, Devizeb, Dipher, Dithane Z-78, Ditiamina, Ditiozin, Enozin, Hexathane, Kypzin, Lonacol, Parzate, Polyram-Z, Pomarsol-Z, Sperlox-Z, Tiezene, Tritoftorol, Zebtox, Zidan, Zimate, Zinosan

Action: Fungicide

Properties: A light-colored powder soluble in water at 10 mg/L.

Field Applications and Formulations: Zineb is a protective dithiocarbamate foliar fungicide that is also used as a seed and soil treatment. Apples and oranges are the two major agricultural crops, although zineb is applied to several other crops. Zineb is formulated in dusts (3.25 to 15%), flowable (0.479 kg/L; 4 lb/gal), and wettable powder (1.4 to 75%). It is also available in combination with other fungicides.

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	M	A	tech	>5,000		80
	F	A	tech	>5,000		80
Mallard	M	11–12	95	>2,000		264
Ring-necked pheasant	F	3–4	95	>2,000		264

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	M	A	tech	>2,500			80
	F	A	tech	>2,500			80
Japanese quail	U	0.5	85		>5,000	No overt signs of toxicity to 5,000 ppm	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Zineb is one of the ethylene bisdithiocarbamates (EBDC) used as an agricultural fungicide. Residues of the EBDC fungicides are generally rapidly degraded (Food and Drug Administration 1982). The bioconcentration factor for zineb, predicted from water solubility, is low.

Zineb has low acute oral toxicity to rats, mallards, and ring-necked pheasants. Its dermal toxicity to rats is also low. Domestic sheep that ingested 361 g zineb as 15 daily doses, at a rate of 500 mg/kg body weight, showed severe toxicosis and death in 3 weeks (Palmer 1963). The degradation product, ethylene thiourea (ETU), has been found to have teratogenic, antithyroid, and tumorogenic effects in mice and rats (Food and Drug Administration 1982). Although there have been no reports of zineb use resulting in adverse effects on wildlife, and its apparent acute toxicity is low, its chronic effects on wildlife have not been evaluated.

Ziram

CAS #137-30-4

Toxicity Class: IV **Use Class:** V

Chemical Name: Bis(dimethyldithiocarbamato)zinc

Common and Trade Names: Antene, Carbazine, Corozate, Cumin, Drupina, Fuklasin, Fungostop, Mezene, Milbam, Pomarsol Z Forte, Prodaram, Tricarbamix, Triscabol, Z-C Spray, Zerlate, Zincmate, Zinkcarbamate, Ziram Technical, Ziramvis, Zirasan, Zirberk, Zirex, Ziride, Zitox

Action: Fungicide

Properties: A white powder soluble in water at 65 mg/L. It is stable under nonacidic conditions.

Field Applications and Formulations: Ziram is a metallic dithiocarbamate used as a protective foliar fungicide. It is also used as a soil treatment, seed treatment, and as a bird and rodent repellent (Worthing 1979; Thomson 1982). Ziram is applied to several different crops, with major use on almonds. It is formulated as dust (3.25–15%), flowable (0.479 kg/L; 4 lb/gal), and wettable powder (76, 88, and 96%).

Acute Oral Toxicity Summary

Test animal	Sex	Age (months)	Purity (%) or grade	LD50 (mg/kg)	LD50 95% CL (mg/kg)	Reference
Rat	U	U	U	1,400		11
European starling	U	U	U		Not toxic at 100 mg/kg	225
Red-winged blackbird	U	U	U	100	(56–178)	225

Dietary, Acute Dermal, and Other Toxicological Test Results

Test animal	Sex	Age (months)	Purity (%) or grade	AD LD50 (mg/kg)	Dietary LC50 (ppm)	LC50 95% CL (ppm) or other toxicity tests	Reference
Rat	U	U	U			1-year dietary "no effect" level of 5 mg AI/kg per day	285
	U	I	U			30-day dietary "no effect" level of 100 ppm in the diet for weanling rats	285
Japanese quail	U	0.5	100		3,346	(2,664–4,430)	122

Effects of Field Applications and Field Tests on Wildlife: None found in the literature.

Persistence and Hazard Evaluation: Ziram is applied as a foliar fungicide and has moderately low field use relative to other carbamate pesticides. Little information is available on the environmental persistence and fate of ziram. It is the most stable of the metallic dithiocarbamate fungicides and does not accumulate in soils (Thomson 1982). The bioconcentration factor of ziram, predicted from water solubility, is low.

Ziram has low acute oral toxicity to rats and is not toxic to starlings at 100 mg/kg (Schafer 1972). It was, however, toxic to red-winged blackbirds with an acute oral LD50 of 100 mg/kg. There have been no reports of ziram use resulting in adverse effects to wildlife. Toxicological data are few and variable, and further toxicity testing with wildlife species is needed in order to define its overall hazard to wildlife.

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Appendix A. Species Referenced in the Text

Mammals

Cat, domestic	*Felis catus*
Cattle, domestic	*Bos taurus*
Cotton rat	*Sigmodon hispidus*
Cottontail, eastern	*Sylvilagus floridanus*
Dog, domestic	*Canis familiaris*
Goat, domestic	*Capra hircus*
Gray squirrel	*Sciurus carolinensis*
Guinea pig	*Cavia porcellus*
Jackrabbit	*Lepus* spp.
Mouse	*Mus musculus*
Mule deer	*Odocoileus hemionus*
Rabbit, white	*Oryctolagus cuniculus*
Rat, albino	*Rattus norvegicus*
Rhesus monkey	*Macaca mulatta*
Sheep, domestic	*Ovis aries*
White-footed mouse	*Peromyscus leucopus*

Birds

American black duck	*Anas rubripes*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American kestrel	*Falco sparverius*
American robin	*Turdus migratorius*
American wigeon	*Anas americana*
Bald eagle	*Haliaeetus leucocephalus*
Black-billed magpie	*Pica pica*
Black-crowned night-heron	*Nycticorax nycticorax*
Blue grouse	*Dendragapus obscurus*
California quail	*Callipepla californica*
Canada goose	*Branta canadensis*
Cedar waxwing	*Bombycilla cedrorum*
Chicken, domestic	*Gallus domesticus*
Chukar	*Alectoris chukar*
Common grackle	*Quiscalus quiscula*
Dark-eyed junco	*Junco hyemalis*
European starling	*Sturnus vulgaris*
Franklin's gull	*Larus pipixcan*
Fulvous whistling-duck	*Dendrocygna bicolor*
Gadwall	*Anas strepera*
Golden eagle	*Aquila chrysaetos*
Great-tailed grackle	*Quiscalus mexicanus*
Graylag goose	*Anser anser*
Gray partridge	*Perdix perdix*
Green-winged teal	*Anas crecca*
Horned lark	*Eremophila alpestris*
House finch	*Carpodacus mexicanus*
House sparrow	*Passer domesticus*
Japanese quail	*Coturnix japonica*
Killdeer	*Charadrius vociferus*
Laughing gull	*Larus atricilla*
Mallard	*Anas platyrhynchos*
Mourning dove	*Zenaida macroura*
Northern bobwhite	*Colinus virginianus*
Northern harrier	*Circus cyaneus*
Northern mockingbird	*Mimus polyglottos*
Northern parula	*Parula americana*
Northern pintail	*Anas acuta*
Pink-footed goose	*Anser brachyrhynchus*
Red-eyed vireo	*Vireo olivaceus*
Red-legged partridge	*Alectoris rufa*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Ringed turtle-dove	*Streptopelia risoria*
Ring-necked pheasant	*Phasianus colchicus*
Rock dove	*Columba livia*
Sandhill crane	*Grus canadensis*
Sharp-tailed grouse	*Tympanuchus phasianellus*
Tree swallow	*Tachycineta bicolor*
White-winged dove	*Zenaida asiatica*
Wild turkey	*Meleagris gallopavo*

Amphibians

Bullfrog	*Rana catesbeiana*
Cricket frog	*Acris crepitans*

Appendix B. Acute Oral Rat LD50's for Organophosphorus and Carbamate Pesticides

Table 1B. *The lowest acute oral rat LD50 value, for technical-grade organophosphorus pesticides, reported in the literature. When technical-grade values are not listed, the lowest value reported in the literature is given.*

Common name	Acute oral rat LD50 (mg/kg)	Common name	Acute oral rat LD50 (mg/kg)
Acephate	866	Fenamiphos	8
Akton	146	Fenitrothion	570
Aspon	2,710	Fensulfothion	2
Azinphos-methyl	5	Fenthion	255
Bensulide	271	Fonofos	8
Bomyl	31	Glyphosate	4,300
Bromophos	1,600	Isofenphos	28
Butonate	1,100	Malathion	1,000
Carbophenothion	6.80	Methamidophos	18
Chlorfenvinphos	10	Methidathion	44
Chlorpyrifos	97	Methyl parathion	9
Coumaphos	16	Methyl trithion	98
Crotoxyphos	74	Mevinphos	3.70
Crufomate	770	Monocrotophos	8
Cythioate	160	Naled	250
DDVP (dichlorvos)	56	Oxydemeton-methyl	47
DEF	150	Parathion	3.60
Demeton	2.50	Phorate	2
Demeton-methyl	64	Phosalone	120
DEP, 2,4-	850	Phosfon	178
Dialifor	43	Phosmet	113
Diamidfos	140	Phosphamidon	17
Diazinon	300	Pirimiphos-ethyl	40
Dicapthon	330	Profenofos	400
Dichlofenthion	270	Propetamphos	119
Dicrotophos	16	Ronnel	1,250
Dimethoate	28	Sulfotep	7
Dioxathion	23	Sulprofos	107
Disulfoton	2	Temephos	2,030
EPN	26	TEPP	1.05
Ethephon	4,229	Terbufos	4.50
Ethion	27	Tetrachlorvinphos	4,000
Ethoprop	61.50	Trichlorfon	144
Famphur	36		

Table 2B. *The lowest acute oral rat LD50 value, for technical-grade carbamate pesticides, reported in the literature. When technical-grade values are not listed, the lowest value reported is given.*

Common name	Acute oral rat LD50 (mg/kg)	Common name	Acute oral rat LD50 (mg/kg)
Aldicarb	0.9	Metham	820
Aldoxycarb	26.8	Methiocarb	15
Aminocarb	30	Methomyl	17
Asulam	5,000	Metiram	10,000
Barban	1,350	Mexacarbate	19
Bendiocarb	40	Molinate	549
Benomyl	10,000	Nabam	395
Bufencarb	87	Oxamyl	5.4
Butylate	3,500	Pebulate	921
Carbaryl	500	Phenmedipham	8,000
Carbofuran	11	Propham	5,000
CDEC	850	Propoxur	83
Chlorpropham	3,800	Thiobencarb	920
Cycloate	2,000	Thiophanate	>10,000
Desmedipham	10,250	Thiophanate-methyl	6,640
Diallate	395	Thiram	780
EPTC	1,630	Triallate	1,675
Ferbam	>4,000	Vernolate	1,780
Formetanate	20	Zineb	5,200
Mancozeb	>8,000	Ziram	1,400
Maneb	6,750		

Appendix C. Abbreviations Frequently Used in the Text

A	adult
ACh	acetylcholine
AChE	acetylcholinesterase
AD	acute dermal
AI	active ingredient
B	bait
BCF	bioconcentration factor
BChE	butyrylcholinesterase
CAS	chemical abstract service registry number
ChE	cholinesterase
CL	confidence limits
D	dust
EC	emulsifiable concentrate
EPA	Environmental Protection Agency
f	flow-through water system
F	female
G	granular
gal	gallon
h	hour
ha	hectare
I	immature
IUPAC	International Union of Pure and Applied Chemists
kg	kilogram
L	liter
lb	pound
LC	lethal concentration (median)
LD	lethal dosage (median)
LH	luteinizing hormone
M	male
mi	mile
mg	milligram
oz	ounce
PIMS	EPA Pesticide Incident Monitoring System
ppm	parts per million
RBC	red blood cell
S	spray
SC	spray concentrate
SP	soluble powder
t	terrestrial-aquatic water system
tech	technical grade
U	unknown
ULV	ultra-low volume
WP	wettable powder

Appendix D. Index to Pesticides

Cross Reference of Pesticides to Common Name

Alternative name	Common name index number (see common name index)	Alternative name	Common name index number (see common name index)
Chemathion	60	Devikol	29
Chem bam	75	Devizeb	106
Chem-hoe	90	Diagran	38
Chem zineb	106	Dianon	38
Chipco thiram	102	Diaterr fos	38
Chlorfonium	86	Diazajet	38
Chlorinat	9	Diazide	38
Chlorofos	104	Diazital	38
Chloro-IPC	23	Diazol	38
Chlorophos	104	Dibrom	76
Chlorphonium	84	Di-captan	39
Ciclosom	104	Dicarbam	18
Ciodrin	26	Dicarzol	57
Ciovap	26	Dichlorofenthion	40
CIPC	23	Dichlorphos	29
Co-ral	25	Dichlorvos	29
Corothion	79	Dicofen	52
Corozate	107	Diethion	48
Correx	11	Diethyl parathion	79
Cotnion-methyl	8	Difenthos	95
Counter	97	Dimate 267	42
Crinex	104	Dimaz	44
Crisodrin	74	Dimecron	85
Crystal zineb	106	Dimethogen	42
Cumin	107	Dimethyl parathion	68
Cunitex	102	Dinosan	101
Curacron	88	Diolice	25
Curaterr	19	Dipher	106
Cycosin	101	Dipterex	104
Cyfen	52	Disan	12
Cyflee	50	Di-syston	44
Cygon	42	Disyston	44
Cypona	26, 29	Dithane	75
Cypona E.C.	26	Dithane M-22	62
Cytel	52	Dithane M-45	61
Cythion	60	Dithane Z-78	106
Dagadip	20	Dithio	93
Dalf	68	Dithiodemeton	44
Danex	104	Dithione	93
Daphene	42	Dithiosystox	44
Dasanit	53	Ditiamina	106
DATC	36	Ditiozin	106
Dazzel	38	Divipan	29
Dedevap	29	Dixon	86
De-fend	42	Dizinon	38
De-green	30	DMSP	53
Delnav	43	Dovip	50
Deltic	43	Dowco 179	24
Demeton-S-methyl sulfoxid	78	Draza	66
Demos L40	42	Drexel parathion 8E	79
Demox	31	Drupina	107
Denapon	18	DSE	75
Detmol	60	Duo-kill	26, 29
Devicarb	18	Duosan	101
Devigon	42	Duraphos	71

Alternative name	Common name index number (see common name index)
Dursban	24
Dybar	52
Dyfonate	56
Dylox	104
Dyzol	38
Easout	101
Ecopro	95
Ectoral	92
Ekatox	79
Ektafos	41
Elbanil	23
Elmosan	11
Embathion	48
Emmatos	60
Emmatos extra	60
Endyl	20
Enovit	100
Enovit-super	101
Enozin	106
Entex	54
EPN	45
Eptam	46
Equigard	29
Equino-aid	104
Eradex	24
Eradicane	46
Ethanox	48
Ethiol	48
Ethodan	48
Ethoprophos	49
Ethrel	47
Ethyl parathon	79
Etilon	79
Etrolene	92
Evershield	102
Exporsan	12
E-Z-off D	30
Falodin	33
Falone	33
Famfos	50, 86
Famophos	50
Fanfos	50
Far-go	103
Fenchlorfos	92
Fenchlorphos	92
Fenitox	52
Fenstan	52
Ferbamate	55
Ferbame	55
Ferberk	55
Fermide	102
Fermocide	55
Fernasan	102
Fernex	87
Ficam	10
Flo pro	102
Flordimex	47
Florel	47
Fly bait grits	13
Fly-die	29
Folidol	79
Folidol-M	68
Folithion	52
Fore	61
Formal	60
Fos-fall "A"	30
Fosfamid	42
Fosferno	79
Fostion MM	42
Frumin AL	44
Fuklasin	107
Fungitox	101
Fungo	101
Fungostop	107
Furadan	19
Furloe	23
Fyfanon	60
Gafgro	47
Gardcide	98
Gardentox	38
Gardona	98
Garrathion	20
Garvox	10
Gesfid	71
Granutox	82
Grex	11
Griffin manex	62
Griffin nu-bait II	67
Gusathion	8
Guthion	8
Hamidop	64
Helothion	94
Herkol	29
Hexaferb	55
Hexathane	106
Hexathir	102
Hexavin	18
Hexylthiocarbam	28
Hibrom	76
Hilthion	60
Hylemox	48
IFC	90
Imidan	85
INPC	90
IPC	90
IPC-400	90
IPPC	90
Isocarb	91
Isofenphos	59
Itopaz	48

Alternative name	Common name index number (see common name index)	Alternative name	Common name index number (see common name index)
Jomix	7	Mercaptodimethur	66
Karbaspray	18	Mercaptophos	31
Karbation	63	Mercaptothion	60
Karbofos	60	Mercuram	102
Kayazinon	38	Merpafos	94
Kayazol	38	Mesurol	66
Kemolate	85	Metacide	68
Killmaster	24	Metacil	5
Kleenup	58	Metafos	68
Klimite 40	96	Metam	63
Knockmate	55	Metam-fluid	63
Knox-out	38	Metam-sodium (monosodium salt)	63
Kop-thion	60	Metasystemox	78
Korlan	92	Metasystox	32
Krecalvin	29	Metasystox-R	78
Kwit	48	Methamidofos estrella	64
Kypfos	60	Methyl carbophenothion	69
Kypman	62	Methyldemeton	32
Kypzin	106	Methyl guthion	8
Labilite	101	Methyl nitran	68
Lannate	67	Metilmercapto fosoksid	78
Lebaycid	54	Metmercapturon	66
Leivasom	104	Metron	68
Lethox	20	Mezene	107
Lignasan	11	Milbam	107
Lindan	29	Mildothane	101
Lonacol	106	MLT	60
Lonocol M	62	Mobilawn	40
Lorsban	24	Mocap	49
M-45	62	Monitor	64
Mafu	29	Monocil 40	74
Malamar	60	Monocron	74
Malaphele	60	Multamat	10
Malaphos	60	Muscatox	25
Malathion ULV concentrate	60	Nabame	75
Malatol	60	Nabasan	75
Malmed	60	Nac	18
Maltox	60	Nankor	92
Mancofol	61	Navon	23
Maneba	62	Neguvon	104
Manebgam	62	Nellite	37
Manesan	62	Nemacur	51
Manex	62	Nemspor	61
Manzate	62	Neobyne	9
Manzati	62	Neocidol	38
Manzeb	61, 62	Nephocarp	20
Manzin	61, 62	Nerkol	29
Maposol	63	Nespor	62
Marvex	29	Netal	14
Masoten	104	Nexion	14
Matacil	5	Nexoval	23
M-diphar	62	Niacide	55
Meldane	25	Nialate	48
Menite	71	Nifos T	96
MEP	52	Nimitox	95

Alternative name	Common name index number (see common name index)
Niomil	10
Nipsan	38
Niran	79
Nitrox	68
Nogos	29
Nomersam	102
No-pest	29
Novathion	52
NPD	6
Nucidol	38
Nudrin	67
Nuvacron	74
Nuvan	29
Nuvanol	52
Oftanol	59
Oko	29
Ordam	73
Orthene	1
Ortho 12420	1
Ortho phosphate defoliant	30
Orthophos	79
Ortil	1
Ortran	1
Panthion	79
Paramar	79
Paraphos	79
Parathene	79
Parawet	79
Partron-M	68
Parzate	75, 106
PEBC	80
Pelt-44	101
Pelt Sol	100
Penncap-M	68
Perfekthion	42
PETD	70
PHC	91
Phenamiphos	51
Phorate 15-G	82
Phosdrin	71
Phosfene	71
Phoskil	79
Phosphon	84
Phosvit	29
Phthalophos	85
Pillardrin	74
Plantdrin	74
PMC	85
Polycar	61
Polycron	88
Polyram	70
Polyram-combi	70
Polyram-M	62
Polyram-ultra	102
Polyram-Z	106
Pomarsol forte	102
Pomarsol-Z	106
Pomarsol Z forte	107
Prefar	12
Premalox	90
Pre-san	12
Prevanol	23
Primicid	87
Primotec	87
Prodaram	107
Prolate	85
Prophos	49
Propion unden	91
Propyon	91
Prothiofos	88
Proxol	104
Pyrinex	24
Rabon	98
Rabond	98
Rampart	82
Ravyon	18
Rebelate	42
Remasan	62
Resistox	25
Resitox	25
Rhodiacide	48
Rhodiatox	79
Rhodocide	48
Rogodial	42
Rogor	42
Ro-neet	28
Roundup	58
Rovokil	49
Roxion	42
Rubitox	83
Ruelene	27
S1752	54
Safrotin	89
Sapecron	22
Sarolex	38
Saturn	99
Saturno	99
Seedox	10
Selecron	88
Septene	18
Sendran	91
Sevin	18
Sigma	101
Sistan	63
SNP	79
Solasan	63
Solgard	87
Solvirex	44
Sometam	63
Somonic	65

Alternative name	Common name index number (see common name index)	Alternative name	Common name index number (see common name index)
Somonil	65	Thiuramin	102
Soptrathion	79	Thylate	102
Spectracide	38	Tiezene	106
Sperlox-Z	106	Tiguvon	54
Spotrete	102	Tillam	80
Spring-bak	75	Timet	82
Sprout-nip	23	Tirampa	102
Spud-nic	23	Topsin	100
Standak	4	Topsin-E	100
Stathion	79	Topsin-M	101
Steladone	22	Torak	35
Stirofos	98	Tornado	1
Stopgerme-S	23	Trametan	102
Sulfallate	21	Trevin	101
Sulfotepp	93	Tribuphon	16
Sumanone	52	Tricarbamix	107
Sumithion	52	Tricarnam	18
Sumitox	60	Trichlorophon	104
Suncide	91	Trichlorphon	104
Supona	22	Trifungol	55
Supracide	65	Triherbide	90
Sup'r-flo ferbam flowable	55	Triherbide-CIPC	23
Surpass	105	Trimangol	62
Susvin	74	Trimaton	63
Sutan	17	Trimetion	42
Sutan + (butylate combined with R-25788)	17	Trinex	104
		Tripomol	102
Swat	13	Triscabol	107
Swebate	95	Trithion	20
Systemox	31	Tritoftorol	106
Systox	31	Trolene	92
Tahmabon	64	T seed protectant	102
Tamaron	64	Tuads	102
Task	29	Tuberite	90
Taterpex	23	Tubothane	62
Tattoo	10	Tugon	104
Tekwaisa	68	Tugon fliegenkugel	91
Temik	3	Turcam	10
Tep	96	Ultracide	65
Tercyl	18	Ultra-sofril	11
Terracur-P	53	Umbethion	25
Tersan	102	Unden	91
Tersan-1991	11	Undene	91
Tersan-LSR	62	Unicrop CIPC	23
Tetrapom	102	Unicrop maneb	62
Tetron	96	Unitox	22
Thimer	102	Vancide	55, 62, 102
Thimet	82	Vapam	63
Thiodemeton	44	Vapona	29
Thioknock	102	Vaponite	29
Thiophos	79	Vapotone	96
Thiotepp	93	VC9-104	49
Thiotex	102	Vegedex	21
Thiramad	102	Vegfru foratox	82
Thirasan	102	Vegfru fosmite	48

Index to Pesticides by Common Name

Smith, Gregory J. 1987. **Pesticide Use and Toxicology in Relation to Wildlife: Organophosphorus and Carbamate Compounds.** *U.S. Fish Wildl. Serv., Resour. Publ.* 170. 171 pp.

More than 89 million acre-treatments of organophosphorus and carbamate pesticides are applied each year within the United States. These compounds are applied to agricultural lands, rangelands, and forests in every region of the country and in every State. Of the organophosphorus and carbamate pesticides contributing to more than 50% of the total use, all but one of these chemicals is classified as highly toxic. Therefore, most of the potential hazard to nontarget species is produced by only a few widely used and highly toxic chemicals. Tabular information summarizing chemical characteristics and hazard evaluations is presented for 67 organophosphorus and 41 carbamate compounds.

Key words: Organophosphorus, carbamates, pesticides, wildlife, toxic effects, wildlife die-offs, insecticides, herbicides, fungicides.

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A list of current *Resource Publications* follows.

157. The Breeding Bird Survey: Its First Fifteen Years, 1965–1979, by Chandler S. Robbins, Danny Bystrak, and Paul H. Geissler. 1986. 196 pp.
158. Techniques for Studying Nest Success of Ducks in Upland Habitats in the Prairie Pothole Region, by Albert T. Klett, Harold F. Duebbert, Craig A. Faanes, and Kenneth F. Higgins. 1986. 24 pp.
159. Research and Development Series: An Annotated Bibliography, 1889–1985, compiled by Thomas J. Cortese and Barbara A. Groshek. In press.
160. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals, by Foster L. Mayer and Mark R. Ellersieck. 1986. 579 pp.
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166. Checklist of Vertebrates of the United States, the U.S. Territories, and Canada, by Richard C. Banks, Roy W. McDiarmid, and Alfred L. Gardner. 1987. 79 pp.
167. Field Guide to Wildlife Diseases. Vol. 1. General Field Procedures and Diseases of Migratory Birds, by Milton Friend, Cynthia J. Laitman, and Randy Stothard Kampen. 1987.
168. Mourning Dove Nesting: Seasonal Patterns and Effects of September Hunting, by Paul H. Geissler, David D. Dolton, Rebecca Field, Richard A. Coon, H. Franklin Percival, Don W. Hayne, Lawrence D. Soileau, Ronnie R. George, James H. Dunks, and S. Dwight Bunnell. 1987. 33 pp.
169. Saltcedar Control for Wildlife Habitat Improvement in the Southwestern United States, by Theodore A. Kerpez and Norman S. Smith. 1987. 16 pp.