Oxyfluorfen

Analysis of Risks
to
Endangered and Threatened Salmon and Steelhead

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Summary

Oxyfluorfen is a pre-emergent and post-emergent broadleaf and grassy weed herbicide and is registered for use on a variety of field, fruit, and vegetable crops, ornamentals as well as non-crop sites. Oxyfluorfen is formulated for agricultural uses as an emulsifiable liquid concentrate and as a granular product, although it is most frequently used in a liquid formulation for food crops and as a granular formulation for ornamental nursery crops. There are also several ready-to-use products and a liquid concentrate available for residential use. Residential formulations contain 0.25% to 0.70% oxyfluorfen by volume and are packaged in a ready-to-use (RTU) sprinkler jug, a RTU trigger sprayer or as a liquid to be mixed in a sprinkler can or tank sprayer (EPA 2000). Oxyfluorfen is formulated with other active ingredients including oryzalin, glyphosate, pendamethalin, and Imazapyr. Oxyfluorfen is registered for residential use.

An endangered species risk assessment is developed for federally listed Pacific salmon and steelhead. This assessment applies the findings of the Office of Pesticide Program's Environmental Risk Assessment developed for non-target fish and wildlife as part of the reregistration process to determine the potential risks to the 26 listed threatened and endangered Evolutionarily Significant Units (ESUs) of Pacific salmon and steelhead. The use of oxyfluorfen will have no direct or indirect effect from loss of food supply or loss of cover in the 26 ESUs of Pacific salmon and steelhead when used according to labeled application directions.

Introduction

This analysis was prepared by the U.S. Environmental Protection Agency (EPA) Office of Pesticides Programs (OPP) to evaluate the risks of oxyfluorfen to threatened and endangered Pacific salmon and steelhead. The format of this analysis is the same as for previous analyses. The background section explaining the risk assessment process is the same as was presented in a previous assessment for diazinon, except that we have updated our criteria for indirect effects on aquatic plant cover to bring this in line with the acute risk concerns used by the Environmental

Fate and Effects Division of OPP (EFED). Several other minor wording changes have also been made that have no bearing on the technical analysis.

The general aquatic risk assessment presented in the "Reregistration Eligibility Decision (RED) Oxyfluorfen" signed on December 2000 was the starting basis for this assessment (Attachment A). This document (USEPA, 2000) is on line at: http://cfpub.epa.gov/oppref/rereg/status.cfm?show=rereg#O.

Problem Formulation: The purpose of this analysis is to determine whether the registration of Oxyfluorfen as a herbicide for use on various treatment sites may affect threatened and endangered (T&E or listed) Pacific anadromous salmon and steelhead and their designated critical habitat.

Scope: Although this analysis is specific to listed Pacific anadromous salmon and steelhead and the watersheds in which they occur, it is acknowledged that Oxyfluorfen is registered for uses that may occur outside this geographic scope and that additional analyses may be required to address other T&E species in the Pacific states as well as across the United States. We understand that any subsequent analyses, requests for consultation and resulting Biological Opinions may necessitate that Biological Opinions relative to this request be revisited, and could be modified.

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A. Reregistration Eligibility Decision (RED)
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1. Background

Under section 7 of the Endangered Species Act, the Office of Pesticide Programs (OPP) of the U. S. Environmental Protection Agency (EPA) is required to consult on actions that 'may affect' Federally listed endangered or threatened species or that may adversely modify designated critical habitats. Situations where a pesticide may affect a fish, such as any of the salmonid species listed by the National Marine Fisheries Service (NMFS), include either direct or indirect effects on the fish. Direct effects result from exposure to a pesticide at levels that may cause harm.

Acute Toxicity - Relevant acute data are derived from standardized toxicity tests with lethality as the primary endpoint. These tests are conducted with what is generally accepted as the most sensitive life stage of fish, i.e., very young fish from 0.5-5 grams in weight, and with species that are usually among the most sensitive. These tests for pesticide registration include analysis of observable sublethal effects as well. The intent of acute tests is to statistically derive a median effect level; typically the effect is lethality in fish (LC50) or immobility in aquatic invertebrates (EC50). Typically, a standard fish acute test will include concentrations that cause no mortality, and often no observable sublethal effects, as well as concentrations that would cause 100% mortality. By looking at the effects at various test concentrations, a dose-response curve can be derived, and one can statistically predict the effects likely to occur at various pesticide concentrations; a well-done test can even be extrapolated, with caution, to concentrations below those tested (or above the test concentrations if the highest concentration did not produce 100% mortality).

OPP typically uses qualitative descriptors to describe different levels of acute toxicity, the most likely kind of effect of modern pesticides (Table 1). These are widely used for comparative purposes, but must be associated with exposure before any conclusions can be drawn with respect to risk. Pesticides that are considered highly toxic or very highly toxic are required to have a label statement indicating that level of toxicity. The FIFRA regulations [40CFR158.490(a)] do not require calculating a specific LC50 or EC50 for pesticides that are practically non-toxic; the LC50 or EC50 would simply be expressed as >100 ppm. When no lethal or sublethal effects are observed at 100 ppm, OPP considers the pesticide will have "no effect" on the species.

Table 1. Qualitative descriptors for categories of fish and aquatic invertebrate toxicity (from Zucker, 1985)

LC50 or EC50	Category description
< 0.1 ppm	Very highly toxic
0.1- 1 ppm	Highly toxic
>1 < 10 ppm	Moderately toxic
> 10 < 100 ppm	Slightly toxic
> 100 ppm	Practically non-toxic

Comparative toxicology has demonstrated that various species of scaled fish generally have equivalent sensitivity, within an order of magnitude, to other species of scaled fish tested under the same conditions. Sappington et al. (2001), Beyers et al. (1994) and Dwyer et al. (1999), among others, have shown that endangered and threatened fish tested to date are similarly sensitive, on an acute basis, to a variety of pesticides and other chemicals as their non-endangered counterparts.

Chronic Toxicity - OPP evaluates the potential chronic effects of a pesticide on the basis of several types of tests. These tests are often required for registration, but not always. If a pesticide has essentially no acute toxicity at relevant concentrations, or if it degrades very rapidly in water, or if the nature of the use is such that the pesticide will not reach water, then chronic fish tests may not be required [40CFR158.490]. Chronic fish tests primarily evaluate the potential for reproductive effects and effects on the offspring. Other observed sublethal effects are also required to be reported. An abbreviated chronic test, the fish early-life stage test, is usually the first chronic test conducted and will indicate the likelihood of reproductive or chronic effects at relevant concentrations. If such effects are found, then a full fish life-cycle test will be conducted. If the nature of the chemical is such that reproductive effects are expected, the abbreviated test may be skipped in favor of the full life-cycle test. These chronic tests are designed to determine a "no observable effect level" (NOEL) and a "lowest observable effect level" (LOEL). A chronic risk requires not only chronic toxicity, but also chronic exposure, which can result from a chemical being persistent and resident in an environment (e.g., a pond) for a chronic period of time or from repeated applications that transport into any environment such that exposure would be considered "chronic".

As with comparative toxicology efforts relative to sensitivity for acute effects, EPA, in conjunction with the U. S. Geological Survey, has a current effort to assess the comparative toxicology for chronic effects also. Preliminary information indicates, as with the acute data, that endangered and threatened fish are again of similar sensitivity to similar non-endangered species.

Metabolites and Degradates - Information must be reported to OPP regarding any pesticide metabolites or degradates that may pose a toxicological risk or that may persist in the environment [40CFR159.179]. Toxicity and/or persistence test data on such compounds may be required if, during the risk assessment, the nature of the metabolite or degradate and the amount that may occur in the environment raises a concern. If actual data or structure-activity analyses are not available, the requirement for testing is based upon best professional judgement.

Inert Ingredients - OPP does take into account the potential effects of what used to be termed "inert" ingredients, but which are beginning to be referred to as "other ingredients". OPP has classified these ingredients into several categories. A few of these, such as nonylphenol, can no longer be used without including them on the label with a specific statement indicating the potential toxicity. Based upon our internal databases, we can find no product in which nonylphenol is now an ingredient. Many others, including such ingredients as clay, soybean oil, many polymers, and chlorophyll, have been evaluated through structure-activity analysis or data and determined to be of minimal or no toxicity. There exist also two additional lists, one for inerts with potential toxicity which are considered a testing priority, and one for inerts unlikely to be toxic, but which cannot yet be said to have negligible toxicity. Any new inert ingredients are required to undergo testing unless it can be demonstrated that testing is unnecessary.

The inerts efforts in OPP are oriented only towards toxicity at the present time, rather than risk. It should be noted, however, that very many of the inerts are in exceedingly small amounts in pesticide products. While some surfactants, solvents, and other ingredients may be present in fairly large amounts in various products, many are present only to a minor extent. These include such things as coloring agents, fragrances, and even the printers ink on water soluble bags of pesticides. Some of these could have moderate toxicity, yet still be of no consequence because of the negligible amounts present in a product. If a product contains inert ingredients in sufficient quantity to be of concern, relative to the toxicity of the active ingredient, OPP attempts to evaluate the potential effects of these inerts through data or structure-activity analysis, where necessary.

For a number of major pesticide products, testing has been conducted on the formulated end-use products that are used by the applicator. The results of fish toxicity tests with formulated products can be compared with the results of tests on the same species with the active ingredient only. A comparison of the results should indicate comparable sensitivity, relative to the percentage of active ingredient in the technical versus formulated product, if there is no extra activity due to the combination of inert ingredients. We note that the "comparable" sensitivity must take into account the natural variation in toxicity tests, which is up to 2-fold for the same species in the same laboratory under the same conditions, and which can be somewhat higher between different laboratories, especially when different stocks of test fish are used.

The comparison of formulated product and technical ingredient test results may not provide specific information on the individual inert ingredients, but rather is like a "black box" which sums up the effects of all ingredients. We consider this approach to be more appropriate than testing each individual inert and active ingredient because it incorporates any additivity, antagonism, and synergism effects that may occur and which might not be correctly evaluated from tests on the individual ingredients. We do note, however, that we do not have aquatic data on most formulated products, although we often have testing on one or perhaps two formulations of an active ingredient.

Risk - An analysis of toxicity, whether acute or chronic, lethal or sublethal, must be combined with an analysis of how much will be in the water, to determine risks to fish. Risk is a combination of exposure and toxicity. Even a very highly toxic chemical will not pose a risk if there is no exposure, or very minimal exposure relative to the toxicity. OPP uses a variety of chemical fate and transport data to develop "estimated environmental concentrations" (EECs) from a suite of established models. The development of aquatic EECs is a tiered process.

The first tier screening model for EECs is with the GENEEC program, developed within OPP, which uses a generic site (in Yazoo, MS) to stand for any site in the U. S. The site choice was intended to yield a maximum exposure, or "worst-case," scenario applicable nationwide, particularly with respect to runoff. The model is based on a 10 hectare watershed that surrounds a one hectare pond, two meters deep. It is assumed that all of the 10 hectare area is treated with the pesticide and that any runoff would drain into the pond. The model also incorporates spray drift, the amount of which is dependent primarily upon the droplet size of the spray. OPP assumes that if this model indicates no concerns when compared with the appropriate toxicity data, then further analysis is not necessary as there would be no effect on the species.

It should be noted that prior to the development of the GENEEC model in 1995, a much more crude approach was used to determining EECs. Older reviews and Reregistration Eligibility Decisions (REDs) may use this approach, but it was excessively conservative and does not provide a sound basis for modern risk assessments. For the purposes of endangered species consultations, we will attempt to revise this old approach with the GENEEC model, where the old screening level raised risk concerns.

When there is a concern with the comparison of toxicity with the EECs identified in GENEEC model, a more sophisticated PRZM-EXAMS model is run to refine the EECs if a suitable scenario has been developed and validated. The PRZM-EXAMS model was developed with widespread collaboration and review by chemical fate and transport experts, soil scientists, and agronomists throughout academia, government, and industry, where it is in common use. As with the GENEEC model, the basic model remains as a 10 hectare field surrounding and draining into a 1 hectare pond. Crop scenarios have been developed by OPP for specific sites, and the model uses site-specific data on soils, climate (especially precipitation), and the crop or site. Typically, site-scenarios are developed to provide for a worst-case analysis for a particular crop in a particular geographic region. The development of site scenarios is very time consuming; scenarios have not yet been developed for a number of crops and locations. OPP attempts to match the crop(s) under consideration with the most appropriate scenario. For some of the older OPP analyses, a very limited number of scenarios were available.

One area of significant weakness in modeling EECs relates to residential uses, especially by homeowners, but also to an extent by commercial applicators. There are no usage data in OPP that relate to pesticide use by homeowners on a geographic scale that would be appropriate for an assessment of risks to listed species. For example, we may know the maximum application rate for a lawn pesticide, but we do not know the size of the lawns, the proportion of the area in lawns, or the percentage of lawns that may be treated in a given geographic area. There is limited information on soil types, slopes, watering practices, and other aspects that relate to transport and fate of pesticides. We do know that some homeowners will attempt to control pests with chemicals and that others will not control pests at all or will use non-chemical methods. We would expect that in some areas, few homeowners will use pesticides, but in other areas, a high percentage could. As a result, OPP has insufficient information to develop a scenario or address the extent of pesticide use in a residential area. It is also important to note that pesticides used in urban areas can be expected to transport considerable distances if they should run off on to concrete or asphalt, such as with streets (e.g., TDK Environmental, 2001). This makes any quantitative analysis very difficult to address aquatic exposure from home use. It also indicates that a no-use or no-spray buffer approach for protection, which we consider quite viable for agricultural areas, may not be particularly useful for urban areas.

Finally, the applicability of the overall EEC scenario, i.e., the 10 hectare watershed draining into a one hectare farm pond, may not be appropriate for a number of T&E species living in rivers or lakes. This scenario is intended to provide a "worst-case" assessment of EECs, but very many T&E fish do not live in ponds, and very many T&E fish do not have all of the habitat surrounding their environment treated with a pesticide. OPP does believe that the EECs from the farm pond model do represent first order streams, such as those in headwaters areas (Effland, et al. 1999). In many agricultural areas, those first order streams may be upstream from pesticide use, but in other areas, or for some non-agricultural uses such as forestry, the first order streams may receive pesticide runoff and drift. However, larger streams and lakes will very likely have lower, often considerably lower, concentrations of pesticides due to more dilution by the receiving waters. In addition, where persistence is a factor, streams will tend to carry pesticides away from where they enter into the streams, and the models do not allow for this. The variables in size of streams, rivers, and lakes, along with flow rates in the lotic waters and seasonal variation, are large enough to preclude the development of applicable models to represent the diversity of T&E species' habitats. We can simply qualitatively note that the farm pond model is expected to overestimate EECs in larger bodies of water.

Indirect Effects - We also attempt to protect listed species from indirect effects of pesticides. We note that there is often not a clear distinction between indirect effects on a listed species and adverse modification of critical habitat (discussed below). By considering indirect effects first, we can provide appropriate protection to listed species even where critical habitat has not been designated. In the case of fish, the indirect concerns are routinely assessed for food and cover.

The primary indirect effect of concern would be for the food source for listed fish. These are best represented by potential effects on aquatic invertebrates, although aquatic plants or plankton may be relevant food sources for some fish species. However, it is not necessary to protect individual organisms that serve as food for listed fish. Thus, our goal is to ensure that pesticides will not impair populations of these aquatic arthropods. In some cases, listed fish may feed on other fish. Because our criteria for protecting the listed fish species is based upon the most sensitive species of fish tested, then by protecting the listed fish species, we are also protecting the species used as prey.

In general, but with some exceptions, pesticides applied in terrestrial environments will not affect the plant material in the water that provides aquatic cover for listed fish. Application rates for herbicides are intended to be efficacious, but are not intended to be excessive. Because only a portion of the effective application rate of an herbicide applied to land will reach water through runoff or drift, the amount is very likely to be below effect levels for aquatic plants. Some of the applied herbicides will degrade through photolysis, hydrolysis, or other processes. In addition, terrestrial herbicide applications are efficacious in part, due to the fact that the product will tend to stay in contact with the foliage or the roots and/or germinating plant parts, when soil applied. With aquatic exposures resulting from terrestrial applications, the pesticide is not placed in immediate contact with the aquatic plant, but rather reaches the plant indirectly after entering the water and being diluted. Aquatic exposure is likely to be transient in flowing waters. However, because of the exceptions where terrestrially applied herbicides could have effects on aquatic plants, OPP does evaluate the sensitivity of aquatic macrophytes to these herbicides to determine if populations of aquatic macrophytes that would serve as cover for T&E fish would be affected.

For most pesticides applied to terrestrial environment, the effects in water, even lentic water, will be relatively transient. Therefore, it is only with very persistent pesticides that any effects would be expected to last into the year following their application. As a result, and excepting those very persistent pesticides, we would not expect that pesticidal modification of the food and cover aspects of critical habitat would be adverse beyond the year of application. Therefore, if a listed salmon or steelhead is not present during the year of application, there would be no concern. If the listed fish is present during the year of application, the effects on food and cover are considered as indirect effects on the fish, rather than as adverse modification of critical habitat.

Designated Critical Habitat - OPP is also required to consult if a pesticide may adversely modify designated critical habitat. In addition to the indirect effects on the fish, we consider that the use of pesticides on land could have such an effect on the critical habitat of aquatic species in a few circumstances. For example, use of herbicides in riparian areas could affect riparian vegetation, especially woody riparian vegetation, which possibly could be an indirect effect on a listed fish. However, there are very few pesticides that are registered for use on riparian vegetation, and the specific uses that may be of concern have to be analyzed on a pesticide by pesticide basis. In considering the general effects that could occur and that could be a problem for listed salmonids, the primary concern would be for the destruction of vegetation near the stream, particularly vegetation that provides cover or temperature control, or that contributes woody debris to the aquatic environment. Destruction of low growing herbaceous material would be a concern if that destruction resulted in excessive sediment loads getting into the stream, but such increased sediment loads are insignificant from cultivated fields relative to those resulting from the initial cultivation itself. Increased sediment loads from destruction of vegetation could be a concern in uncultivated areas. Any increased pesticide load as a result of destruction of terrestrial herbaceous vegetation would be considered a direct effect and would be addressed through the modeling of estimated environmental concentrations. Such modeling can and does take into account the presence and nature of riparian vegetation on pesticide transport to a body of water.

Risk Assessment Processes - All of our risk assessment procedures, toxicity test methods, and EEC models have been peer-reviewed by OPP's Science Advisory Panel. The data from toxicity tests and environmental fate and transport studies undergo a stringent review and validation process in accordance with "Standard Evaluation Procedures" published for each type of test. In addition, all test data on toxicity or environmental fate and transport are conducted in accordance with Good Laboratory Practice (GLP) regulations (40 CFR Part 160) at least since the GLPs were promulgated in 1989.

The risk assessment process is described in "Hazard Evaluation Division - Standard Evaluation Procedure - Ecological Risk Assessment" by Urban and Cook (1986) (termed Ecological Risk Assessment SEP below), which has been separately provided to National Marine Fisheries Service staff. Although certain aspects and procedures have been updated throughout the years, the basic process and criteria still apply. In a very brief summary: the toxicity information for various taxonomic groups of species is quantitatively compared with the potential exposure information from the different uses and application rates and methods. A risk quotient of toxicity divided by exposure is developed and compared with criteria of concern. The criteria of concern presented by Urban and Cook (1986) are presented in Table 2.

Table 2. Risk-quotient criteria for fish and aquatic invertebrates

Test data	Risk quotient	Presumption
Acute LC50	>0.5	Potentially high acute risk
Acute LC50	>0.1	Risk that may be mitigated through restricted use classification
Acute LC50	>0.05	Endangered species may be affected acutely, including sublethal effects
Chronic NOEC	>1	Chronic risk; endangered species may be affected chronically, including reproduction and effects on progeny
Acute invertebrate LC50	>0.5	May be indirect effects on T&E fish through food supply reduction
Aquatic plant acute EC50	>1.0	May be indirect effects on aquatic vegetative cover for T&E fish

The Ecological Risk Assessment SEP (pages 2-6) discusses the quantitative estimates of how the acute toxicity data, in combination with the slope of the dose-response curve, can be used to predict the percentage mortality that would occur at the various risk quotients. The discussion indicates that using a "safety factor" of 10, as applies for restricted use classification, one individual in 30,000,000 exposed to the concentration would be likely to die. Using a "safety factor" of 20, as applies to aquatic T&E species, would exponentially increase the margin of safety. It has been calculated by one pesticide registrant (without sufficient information for OPP to validate that number), that the probability of mortality occurring when the LC50 is 1/20th of the EEC is 2.39 x 10^{-9}, or less than one individual in ten billion. It should be noted that the discussion (originally part of the 1975 regulations for FIFRA) is based upon slopes of primarily organochlorine pesticides, stated to be 4.5 probits per log cycle at that time. As organochlorine pesticides were phased out, OPP undertook an analysis of more current pesticides based on data reported by Johnson and Finley (1980), and determined that the "typical" slope for aquatic toxicity tests for the "more current" pesticides was 9.95. Because the slopes are based upon logarithmically transformed data, the probability of mortality for a pesticide with a 9.95 slope is again exponentially less than for the originally analyzed slope of 4.5.

The above discussion focuses on mortality from acute toxicity. OPP is concerned about other direct effects as well. For chronic and reproductive effects, our criteria ensures that the EEC is below the no-observed-effect-level, where the "effects" include any observable sublethal effects. Because our EEC values are based upon "worst-case" chemical fate and transport data and a small farm pond scenario, it is rare that a non-target organism would be exposed to such concentrations over a period of time, especially for fish that live in lakes or in streams (best professional judgement). Thus, there is no additional safety factor used for the no-observed-effect-concentration, in contrast to the acute data where a safety factor is warranted because the endpoints are a median probability rather than no effect.

Sublethal Effects - With respect to sublethal effects, Tucker and Leitzke (1979) did an extensive review of existing ecotoxicological data on pesticides. Among their findings was that sublethal effects as reported in the literature did not occur at concentrations below one-fourth to one-sixth of the lethal concentrations, when taking into account the same percentages or numbers affected, test system, duration, species, and other factors. This was termed the "6x hypothesis". Their review included cholinesterase inhibition, but was largely oriented towards externally observable parameters such as growth, food consumption, behavioral signs of intoxication, avoidance and repellency, and similar parameters. Even reproductive parameters fit into the hypothesis when the duration of the test was considered. This hypothesis supported the use of lethality tests for use in assessing ecotoxicological risk, and the lethality tests are well enough established and understood to provide strong statistical confidence, which can not always be achieved with sublethal effects. By providing an appropriate safety factor, the concentrations found in lethality tests can therefore generally be used to protect from sublethal effects.

In recent years, Moore and Waring (1996) challenged Atlantic salmon with diazinon and observed effects on olfaction as relates to reproductive physiology and behavior. Their work indicated that diazinon could have sublethal effects of concern for salmon reproduction. However, the nature of their test system, direct exposure of olfactory rosettes, could not be quantitatively related to exposures in the natural environment. Subsequently, Scholz et al. (2000) conducted a non-reproductive behavioral study using whole Chinook salmon in a model stream system that mimicked a natural exposure that is far more relevant to ecological risk assessment than the system used by Moore and Waring (1996). The Scholz et al. (2000) data indicate potential effects of diazinon on

Chinook salmon behavior at very low levels, with statistically significant effects at nominal diazinon exposures of 1 ppb, with apparent, but non-significant effects at 0.1 ppb.

It would appear that the Scholz et al (2000) work contradicts the 6x hypothesis. The research design, especially the nature and duration of exposure, of the test system used by Scholz et al (2000), along with a lack of dose-response, precludes comparisons with lethal levels in accordance with 6x hypothesis as used by Tucker and Leitzke (1979). Nevertheless, it is known that olfaction is an exquisitely sensitive sense. And this sense may be particularly well developed in salmon, as would be consistent with its use by salmon in homing (Hasler and Scholz, 1983). So the contradiction of the 6x hypothesis is not surprising. As a result of these findings, the 6x hypothesis needs to be re-evaluated with respect to olfaction. At the same time, because of the sensitivity of olfaction and because the 6x hypothesis has generally stood the test of time otherwise, it would be premature to abandon the hypothesis for other sublethal effects until there are additional data.

2. Description and use of Oxyfluorfen

a. Chemical Overview

- **Common Name:** Oxyfluorfen
- **Chemical Name:** 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4- (trifluoromethyl)benzene
- **Chemical family:** Diphenyl ether herbicide
- **Case number:** 2490
- **CAS registry number:** 42874-03-3
- **OPP chemical code:** 111601
- **Empirical formula:** $C_{15}H_{11}ClF_3NO_4$
- **Molecular weight:** 361.72 g/mole
- **Trade and other names:** Goal, Galigan
- **Basic manufacturer:** Dow AgroSciences

Oxyfluorfen is an orange to deep red brown crystalline solid with a melting point of 65-84 ˚C, density of 1.49 g/mL, octanol/water partition coefficient of >20, and vapor pressure of 2.5 x 10^{-7} Torr at 25˚ C. Oxyfluorfen is practically insoluble in water (0.1 ppm), but is readily soluble in most organic solvents.

b. Registered Uses

Food Uses:

Tree fruit/Nut/Vine Crops:
Almonds, apple, apricot, avocado, banana, beechnut, brazil nut, butternut, cashew, cherry, chestnut, chinquapin, citrus (non-bearing), crab apple, dates, feijoa, fig, filbert, grapes, hickory nut, kiwi, loquat, macadamia nut, mango, mayhaw, nectarine, olives, papaya, peach, pear, pecan, persimmon, pistachio, plum, pomegranates, prune, quince, and walnut.

Field Crops:
Artichokes (globe), blackberries, broccoli, cabbage, cacao, cauliflower, clary sage, clover, coffee, corn, cotton, garbanzo beans, garlic, guava, horseradish, jojoba, mint, onions, raspberries, soybeans and taro.

Fallow Bed:
Broccoli, cabbage, cauliflower, cotton, garlic, grapes, kiwi, onion, potato, soybeans, tree fruit/nut/citrus, dry beans.

Fallow Bed (non-food, no tolerance):
Cantaloupe, carrot, cereal grains, celery, conifers, dry beans, peanut (other legumes), pepper, safflower, squash, strawberries, sugarbeet (other root/tuber crops), tomato (other fruiting vegetables), watermelon (other cucurbits).

Non-food Uses:
Ornamental plants/trees/shrubs, conifer seed beds and transplants, cut flowers, forest trees, Christmas tree plantations, rights-of-way/fencerows and non-crop areas (nonagricultural uncultivated areas, roadsides, industrial areas, storage yards, non-grazed meadows and farmsteads.)

Residential Uses: Landscape, curbs/gutters, patios, brick walls, sidewalks/walkways and driveways (USEPA 2000).

c. Application Rates and Methods

Application Methods and Equipment:

Agricultural liquid formulations of oxyfluorfen are applied using large, small or ATV groundboom rigs. Aerial application is used mainly for fallow fields and bulb vegetables. Backpack sprayers can be used in Christmas tree plantations and right-of-way areas. Chemigation is used for over the top application to bulb vegetables and for drip application to some orchard trees, however, chemigation is often prohibited per the product labels. Right-of-way sprayers are used in right-of-way areas. Granular oxyfluorfen is applied to field- and container-grown ornamentals with broadcast spreaders (US EPA 2000).

Application Rates and Frequency:

0.25 - 2.0 lbs ai/acre/application. Typically one or two applications are made in the growing season to prevent weed growth (pre emergent) and/or to kill small weeds (post emergent). Some crops allow a greater number of applications/season, including tropical commodities (e.g. guava, coffee, macadamia nut) in Hawaii and ornamentals (USEPA 2000).

Formulation Types Registered:

Oxyfluorfen is formulated for agricultural uses as an emulsifiable liquid concentrate containing 0.2 to 4 pounds active ingredient (ai) per gallon and as a granular product containing 2% oxyfluorfen by weight. Oxyfluorfen is most frequently used in a liquid formulation for food crops and as a granular formulation for ornamental nursery crops. There are also several ready-to-use products and a liquid concentrate available for residential use. Residential formulations contain 0.25% to 0.70% oxyfluorfen by volume and are packaged in a ready-to-use (RTU) sprinkler jug, a RTU trigger sprayer or as a liquid to be mixed in a sprinkler can or tank sprayer (US EPA 2000).

Table 3. Estimated Usage of oxyfluorfen for Representative Sites (RED)

Crop or Site	Lbs. Active Ingredient Applied (WT Avg)	Percent Crop Treated (Wt Avg)	Percent Crop Treated (Likely Maximum)
Almonds	170,000	43%	86%
Artichokes	4,000	53%	78%
Blackberries	1,000	18%	29%
Corn	7,000	0.02%	0.1%
Cotton	54,000	1%	3%
Figs	3,000	33%	69%
Table grapes	30,000	35%	61%
Wine grapes	240,000	54%	84%
Kiwifruit	1,000	9%	29%
Mint	10,000	18%	26%
Nectarines	5,000	35%	61%
Olives	5,000	13%	21%
Onions, dry	15,000	29%	57%
Peaches	24,000	14%	23%
Plums	6,000	24%	52%
Pomegranates	1,000	26%	54%
Raspberries	1,000	28%	56%
Walnuts	48,000	28%	42%
Total non-agricultureal (pasture, ornamentals, right of way)	41,000	N/A	N/A

Table 4. Sample Label Application Rates for Oxyfluorfen

Product	crop	%a.i	App rate/acre	lbs/acre	Notes
Goal 1.6 E 1.6lbs/gallon	Artichoke (globe)	19.4%	5-10 pts	1-2	
	Broccoli		1.25-2.5 pts	0.25-0.5	
	Citrus		2.5-10 pts	0.5-2.0	
	Conifer		1.25-5 pts	0.25-1.0	
	cotton		1.25-2.5 pts	0.25-0.5	
	cottonwood		5-10	1.0-2.0	
	eucalyptus		5-10	1.0-2.0	
	fallow bed		1.25-2.5	0.25-0.5	
	fallow bed (cotton/soybeans)		1.25-2.5	0.25-0.5	
	mint (ID,OR,WA only) peppermint		2.5-3.75	0.5-0.75	Willamette Valley
	spearmint & peppermint		5-10	1.-2.0	East of Cascades
	onions		0.6-1.25	0.12-0.25	
	onions/seed		0.6	0.12	
	treefruit/nut/vine CA		2.5-10	0.5-2.0	
	all other states		2.5-10	0.5-2.0	
Goal 2XL (2lbs ai)	Artichokes (globe)	23%	4-8 pts	1.0-2.0	
	broccoli/cabbage/cauliflower		1-2 pts	0.25-0.5	
	Citrus (non-bearing)		2-8 pts	0.5-2.0	

	conifer seed bed, transplants, container stock and selected field grown deciduous trees		1-4 pts	0.25-1.0	
	conifer transplants and container stock		4-8	1-2	
	Cotton		1-2	0.25-0.5	
	Cottonwood		4-8	1-2	
	Eucalyptus		4-8pts	1-2	
	Fallow bed		1-2	0.25-0.5	
	Fallow bed (cotton/ soybeans		1-2	0.25-0.5	
	Fallow land (ID, OR, WA)		0.5-2.0	0.12-0.5	
	Garbanzo beans		1	0.25	
	Garlic		1	0.25	California
			0.5-1	0.12-0.25	Western states (ID, OR, and WA)
	Horseradish		2	0.5	
	Jojoba		8	2	
	Mint western states only		4-8	1-2	
	non-crop uses		2-8	0.5-2.0	
	onions		0.5-1	0.12-.25	
	onions for seed		0.5	0.125	
	Treefruit /nut/ vine crops		2- 8 pts	0.5-2.0	CA
	Grapes (non-dormant)		1-2	0.25-0.5	

	Grapes (WA, OR only wine processing)		1-2	0.25-0.5	
	Pistachios, walnuts, almonds (CA only)		1-2	0.25-0.5	

Note : a.i.- active ingredient

d. Oxyfluorfen Usage

A full listing of all uses of oxyfluorfen, with the corresponding use and usage data for each site, has been completed and is in the "Quantitative Use Analysis" document (http://www.epa.gov/oppsrrd1/reregistration/oxyfluorfen/oxyqua.pdf). The data, reported on an aggregate and site (crop) basis, reflect annual fluctuations in use patterns as well as the variability in using data from various information sources.

Based on available pesticide survey usage information for the years 1990 through 1999, an annual estimate of oxyfluorfen's total domestic usage averaged approximately 761,000 pounds a..i. for 1,167,000 acres treated. Use of oxyfluorfen is increasing. From 1992 to 1997 the use of oxyfluorfen increased by 54%, from an estimated 458,000 pounds active ingredient in 1992 to an estimated 705,000 lbs active ingredient in 1997. The largest markets in terms of total pounds active ingredient are wine grapes (32%), almonds (23%), cotton (7%), walnuts (6%), and table grapes (4%). The remaining usage is primarily on apples, corn, raisin grapes, mint, dry onion, ornamentals, peaches, pistachios, prunes, and artichokes. Crops with a high percentage of the total U.S. planted acres treated include wine grapes (54%), artichokes (53%), pistachios (44%), almonds (43%), table grapes and nectarines (35% each), and figs (33%). Most of the usage is in CA, OR, WA and the cotton growing regions along the Mississippi River (USEPA 2000).

The latest information for California pesticide use is for the year 2002 [URL: http://www.cdpr.ca.gov/docs/pur/purmain.htm]. The reported information to the County Agricultural Commissioners includes pounds used, acres treated for agricultural and certain other uses, and the specific location treated. The pounds and acres are reported to the state, but the specific location information is retained at the county level and is not readily available.

Table 4. Reported Use of Oxyfluorfen in California, 1993-2002 (lb ai)

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
419,086	368,036	386,206	429,904	472,887	501,708	422,032	463,337	347,588	425,817

Table 5. Major* Use of Oxyfluorfen by Crop or Site in California in 2002

Crop	Total Pounds of Active Ingredient Used [2]	Number of Applications	Acres Treated
Almond	86,345	8,569	498,092

Apple	2,773	205	3,939
Broccoli	6,603	2781	32,926
Cauliflower	294	1,464	15,805
Cherry	3,697	635	11,812
Cotton	2,8749	1,478	125,476
Fig	3,564	98	5,884
Garlic	4,356	169	20,561
Grape	42,938	3,729	130,898
Grape, wine	95,686	7,648	21,1207
Nectarine	5,317	1,848	23,379
Onion, dry	9,083	1,193	67,026
Outdoor plants in containers	5,620	1,176	4,488
Peach	8,133	2,314	29,707
Pistachio	33,755	1,242	8,2645
Plum	7,636	1,612	19,166
Pomegranate	3,768	83	6,411
Prune	4,424	437	15,384
Rights of Ways	19,700	NR[1]	NR[1]
Soil Fumigation/ Preplant	3,746	428	23,577
Tomato, processing	2,995	284	20,305
Uncultivated, Ag	8,957	1,297	63,693
Uncultivated, non-ag	1,581	95	3,318
Total (all uses)	425,816	44,777	4,384,278 [3]

* Because of the number of crops in which oxyfluorfen is registered for use, this table only addresses the crops with the largest amount of acres treated and lbs of oxyfluorfen used in California.

[1] Oxyfluorfen use was not reported in the number of acres treated and number of applications

[2] California database only reports total number of pounds used. This number should be divided by the application rate to calculated the actual amount used/ application.

[3] Agricultural uses only

The Washington State Department of Agriculture (WSDA) has provided information on the acreage of major oxyfluorfen-treated crops and additional details on amounts used for certain of these crops (WSDA 2004). These are in table 6 ; additional information is in the full report, which is included as Attachment D.

Table 6. Major usage of Oxyfluorfen in Washington (WSDA 2004)

CROP	WASS [1] **2002 EST. ACRES**	**EST. % ACRES TREATED**	**EST. LBS. A.I./ACRE**	# OF APPS	EST. ACRES TREATED	EST. LBS. A.I. APPLIED
Apple	164,000	5.0	1.00	1	8,200	8,200
Apricot	1,300	5.0	1.50	1	65	100
Artichoke, globe	< 50	Acreage is not statistically relevant. See narrative below.				
Carrot, seed	2,500					
Cherry	25,000	18.0	0.12	1	4,500	550
Christmas trees	23,000	< 1.0	1.50	1	150	225
Cole crop, seed	600					
Conifer, seed bed	Unknown					
Cottonwood	40,000	Not typically used. See narrative below.				
Crucifer & cole crop	1,500					
Grape	49,800	30.0	0.68	1	14,940	10,160
Grass, seed	75,000					
Kiwifruit	< 10	Not used on kiwis. See narrative below.				
Mint	33,900	4.0	0.46	1	1,356	624
Nursery stock (field grown)	Unknown					
Onion, dry bulb	17,100	90.0	0.20	1.5	15,400	4,600
Peach & nectarine	4,200	5.0	1.50	1	210	315
Pear	24,800	7.3	1.40	1	1,810	2,550
Plum & prune	1,000	5.0	1.50	1	50	75
Red raspberry	9,500	75.0	0.20	1	7,125	1,425

Information for artichokes, carrots, cole crop seed, conifer, crucifer, grape, grass seed, mint, and nursery stock have not been peer reviewed

"-" indicates information that was not provided by Washington State

There are limited data available on the amount of oxyfluorfen used for Oregon and for "less than major" crops in Washington.

3. General aquatic risk assessment for endangered and threatened species

a. Aquatic toxicity of pesticide

i. Summary of oxyfluorfen Toxicity

There are not many studies available for the toxicity of oxyfluorfen. The studies that are included are from the RED and in the Ecotox (EFED) database. The studies from the RED have been characterized based on the endpoint values.

Table 7. Acute Toxicity of Oxyfluorfen to Freshwater Organisms. (RED)

Species	% a.i.	Endpoint	Toxicity Category and/ or Most Sensitive Endpoint
Acute Freshwater			
Bluegill sunfish	95.0	96hrLC_{50} = 200µg/L	Highly Toxic
Daphnia magna	23.2	48hr EC_{50} = 80µg/L	Very Highly Toxic
Acute Estuarine/ Marine			
Sheepshead Minnow	71.4	96hr LC_{50} >170µg/L	Highly Toxic
Grass shrimp	74.0	96hr LC_{50} = 32µg/L	Very highly Toxic
Chronic Freshwater			
Fathead minnow	71	NOAEC=38 µg/L LOAEC=74 µg/L	Survival, larval length and weight
Daphnia magna	71.8	NOAEC =13 µg/L LOAEC=28 µg/L	Growth (length) reproduction
Aquatic Plants			
Selenastrum capricornutum	23.2	96hr EC_{50}=0.29 µg/L	reduction in growth

Table 8. Acute Toxicity of Oxyfluorfen to Freshwater Fish (EFED Database)

Species	Scientific Name	End Point	% active ingredient	Value (ppb)
Rainbow Trout	Onchorynchus mykiss	LC50	94.0	410
Rainbow Trout	Onchorynchus mykiss	LC50	71.4	250
Bluegill	Lepomis macrochirus	LC50	71.4	210

iv. Toxicity of multiple active ingredient products

Table 9. Fish Toxicity of Other Active Ingredients in Oxyfluorfen Products

Pesticide	Most Sensitive Species	Lowest LC50 Value for Technical Material	Reference
Glyphosate	Bluegill	1.8 ppm	EFED
Oryzalin	Rainbow Trout	3.26 ppm	EFED
Pendimethalin	Sheepshead minnow	0.71 ppm	EFED
Oxadiazon	Rainbow Trout	1.05 ppm	EFED
Imazapyr	Rainbow Trout	6.7 ppm	EFED

iii. Sublethal and Endocrine Effects

Sublethal and endocrine effects are addressed in the RED under endocrine disruptor effects on page 41:

"EPA is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) "may have an effect in humans that is similar to an effect produced by a naturally occurring estrogen, or other endocrine effects as the Administrator may designate." Following recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was scientific basis for including, as part of the program, the androgen and thyroid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that EPA include evaluations of potential effects in wildlife. For pesticides, EPA will use FIFRA and, to the extent that effects in wildlife may help determine whether a substance may have an effects in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allows, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP).

When the appropriate screening and/or testing protocols being considered under the EDSP have been developed, oxyfluorfen may be subject to additional screening and/or testing to better characterize effects related to endocrine disruption."

b. Environmental Fate and Transport

The environmental fate and transport of Oxyfluorfen are presented in the RED on page 27. Assessment of water resources, including surface and ground water monitoring, is on pages 12 -13. EECs and model inputs are on pages 28- 32.

Except for the photolysis in water study (which indicates relatively rapid degradation), laboratory data indicate that oxyfluorfen is persistent (aerobic soil metabolism half-lives of 291 and 294 days in a clay loam soil and 556 and 596 days in a sandy loam soil; and anaerobic soil metabolism half-lives between 554 and 603 days). Adsorption/desorption studies suggest oxyfluorfen is relatively immobile, except perhaps when used on very sandy soils. The most likely route of dissipation is soil binding. Laboratory data suggest that once the soil-bound oxyfluorfen reaches deep or turbid surface water it will persist since it is stable to hydrolysis and since light penetration would be limited; however, it may degrade by photolysis in clear, shallow water. Oxyfluorfen can contaminate surface water through spray drift and runoff; however, it is unlikely to contaminate ground water because it is relatively immobile in the soil column; therefore, the likelihood of leaching is small (USEPA 2000).

Degradates

Degradate products of oxyfluorfen were addressed in the RED environmental fate and transport section:

The major degradate found in the environmental fate studies was 2-chloro-1-(3-ethoxy-4-

hydroxyphenol)-4-(trifluoromethyl) benzene, which was identified in the aqueous photolysis study at ≥10 % of the applied radioactivity. Other degradates were identified in the aqueous photolysis study but not quantified. In the hydrolysis study, 2-chloro-1-(3-hydroxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene was identified at a maximum concentration of 1.2-1.7% of the applied radioactivity. There were no degradates identified in the anaerobic soil metabolism, leaching adsorption/desorption and soil photolysis studies. The Health Effects Division has determined that only parent oxyfluorfen is of toxicological concern for human health risk assessment (US EPA 2000).

c. Incidents

There is one reported incident in the EIIS database with an aquatic organism effect. On August 22, 2000, Fifteen Mile Creek near the Dalles Dam in Oregon was the site of an oxyfluorfen spill. A truck carrying formulated oxyfluorfen (Goal 2XL) crashed on a bridge spilling approximately 20,000 gallons of herbicide into the creek yards from where the creek enters the Columbia River. Two weeks after the spill, samples of filtered and unfiltered water near the spill site contained an average of 32 μg/L and 340 μg/L, respectively. This spill was estimated to cause a 35% decrease in the numbers of adult chinook salmon and a 26% decrease in the numbers of steelhead passing over the Dalles Dam the day immediately following the spill, relative to the day prior to the spill. The spill was also reported to kill thousands of young lampreys. An extensive cleanup operation (removal of water and sediment) removed a majority of the chemical, and the estimated quantity of oxyfluorfen not recovered was less than 1000 gallons (USEPA 2000).

d. Estimated and Actual Concentrations of Oxyfluorfen in water

(1) EECs from models

In the RED(attachment A), PRZM-EXAMS were used to calculate refined EECs. The Pesticide Root ZoneModel (PRZM, version 3.12) simulates pesticides in field runoff and erosion, while the Exposure Analysis Modeling System (EXAMS, version 2.7.95) simulates pesticide fate and transport in an aquatic environment (one hectare body of water, two meters deep). EECs were calculated for surface water using the highest application rate on non-bearing citrus, apples, grapes, walnuts, cotton, and cole crops. Although this only represents a portion of the crops for which oxyfluorfen has a labeled use, it does represent crops with higher application rates and crops which have a large percentage of their total acreage treated with oxyfluorfen. By encompassing crops with large percentages of acreage treated with oxyfluorfen and a large geographic area, some crops with lower maximum application rates were also included in the set of scenarios. For freshwater and estuarine fish, the acute and chronic risk LOCs are not exceeded and for freshwater and estuarine invertebrates the acute risk LOC was only exceeded in citrus scenarios (USEPA 2000).

Most of the sites used in the RED were based on climate and soils relative to the southeastern U.S., and are not likely to be representative of the western U. S. Consequently, additional efforts were made to use more recently developed sites to be more representative of the areas where Pacific salmon and steelhead occur. EFED provided western PRZMS-EXAMS results for the grapes, berries, wheat, almonds, and mint (Attachment E).

In both models, it is considered that a 10-hectare watershed will all be treated with the maximum rate, maximum numbers of applications, and minimum intervals between applications. Runoff and drift from this 10-hectare watershed will go into a 1-hectare pond, 2 meters deep. This is a conservative model for salmon and steelhead. While first order streams may be reasonably predicted for a single application, salmon and steelhead (except sockeye), occur primarily in streams and rivers where natural flow of water, and any contaminants in the water column, will move downstream and preclude continued exposure from a single application. Multiple applications may provide for chronic exposure, most likely in a pulsed mode.

The EEC values of various, mostly western, crops are presented in Tables 10-14.

EECs were requested for representative crops in the ESUs. The environmental fate modeling was conducted to assess relative impact of runoff and spray drift on oxyfluorfen loading into the standard water body. This process was accomplished using a fixed exposure scenario except for spray drift assumptions. The drift scenarios include a no drift scenario (assumes 100 application efficiency and zero drift), aerial application drift scenario (assumes 95% application efficiency and a drift of 5% of the application rate), and ground application drift scenario (assumes 99% application efficiency and a drift of 1% of the application rate). The EEC's for this assessment were further divided into categories of no irrigation, irrigation, no irrigation with no spray drift, and irrigation with spray drift (Attachment E).

Estimated environmental concentrations of oxyfluorfen are shown in the tables below. Spray drift appears to be an important transport process for oxyfluorfen loading into surface waters. For all crops, aerial spray drift contributed to higher environmental concentrations when compared to runoff contributions. For California crop scenarios (almonds and grapes), irrigation seems to reduce the estimated concentrations of oxyfluorfen in water possibly due to dilution effects.

Table 10. 1 in 10 year Estimated Environmental Concentrations of Oxyfluorfen for Almonds in California

Type of Application	Peak (µg /L)	96 hr (µg /L)	21 Day (µg /L)	60 Day (µg /L)	90 Day (µg /L)	Yearly (µg /L)
Ground application No irrigation	10.24	8.89	6.19	4.63	4.30	3.45
Ground application with irrigation	6.10	5.38	3.80	2.78	2.53	1.99
Ground application No irrigation/No spray drift	9.81	8.45	5.80	4.21	3.88	3.14
Ground application with irrigation/No Spray drift	5.24	4.61	3.22	2.24	2.05	1.58
Aerial application No						

irrigation	12.82	11.38	8.36	6.56	6.12	4.91
Aerial application with irrigation	9.08	8.28	6.49	4.97	4.58	3.65
Aerial application No irrigation/No spray drift	9.41	8.11	5.57	4.04	3.72	3.02
Aerial application with irrigation/No spray drift	5.03	4.43	3.09	2.15	1.97	1.51

Table 11. 1 in 10 year Estimated Environmental Concentrations of Oxyfluorfen for Grapes in California

Type of Application	Peak (µg /L)	96 hr (µg /L)	21 Day (µg /L)	60 Day (µg /L)	90 Day (µg /L)	Yearly (µg /L)
Ground application No irrigation	3.90	3.42	2.67	2.33	2.30	1.94
Ground application with irrigation	1.10	1.01	0.87	0.75	0.70	0.56
Ground application No irrigation/No spray drift	3.56	3.08	2.32	1.98	1.84	1.55
Ground application with irrigation/No Spray drift	0.58	0.51	0.32	0.21	0.19	0.16
Aerial application No irrigation	5.98	5.55	5.05	4.44	4.19	3.50
Aerial application with irrigation	4.55	4.12	3.62	3.01	2.79	2.19
Aerial application No irrigation/No spray drift	3.42	2.96	2.23	1.90	1.76	1.47

Table 12. 1 in 10 year Estimated Environmental Concentrations of Oxyfluorfen for Berries in Oregon

Type of Application	Peak (µg /L)	96 hr (µg /L)	21 Day (µg /L)	60 Day (µg /L)	90 Day (µg /L)	Yearly (µg /L)
Aerial application	2.96	2.71	2.34	2.02	1.95	1.68
Aerial application/ No spray drift	1.85	1.68	1.30	1.15	1.13	1.01
Ground application	2.11	1.92	1.50	1.36	1.33	1.19
Ground application/ No						

spray drift	1.93	1.75	1.35	1.20	1.17	1.06

Table 13. 1 in 10 year Estimated Environmental Concentrations of Oxyfluorfen for Wheat in Oregon						
Type of Application	**Peak** (µg /L)	**96 hr** (µg /L)	**21 Day** (µg /L)	**60 Day** (µg /L)	**90 Day** (µg /L)	**Yearly** (µg /L)
Aerial application	4.64	4.28	3.57	3.43	3.29	2.90
Aerial application/ No spray drift	3.74	3.44	2.74	2.60	2.51	2.22
Ground application	4.08	3.76	3.00	2.87	2.77	2.45
Ground application/ No spray drift	3.90	3.59	2.86	2.71	2.62	2.31

Table 14. 1 in 10 year Estimated Environmental Concentrations of Oxyfluorfen for Mint in Oregon						
Type of Application	**Peak** (µg /L)	**96 hr** (µg /L)	**21 Day** (µg /L)	**60 Day** (µg /L)	**90 Day** (µg /L)	**Yearly** (µg /L)
Ground application	10.30	9.38	7.57	6.97	6.65	5.91
Ground application/ No spray drift	9.59	8.71	6.81	6.31	6.02	5.38

(2) Measured residues in the environment

<u>NAWQA data</u>

Monitoring data on oxyfluorfen is available from the NAQWA program as obtained from USGS" data warehouse" at URL
http://infotrek.er.usgs.gov/servlet/page?_pageid=543&_dad=portal30&_schema=PORTAL30 .

Table 15 presents a summary of these monitoring data for the U. S. as a whole, and in study sites in states within the range of Pacific salmon and steelhead. When I visited the NAWQA "data warehouse" in May, 2004, I found a total of 381 samples were available for oxyfluorfen. There were 32 detects for oxyfluorfen; a rate of 8.39% detection.. All of the detections were of very low concentrations with the maximum being 0.08370 ug/L. We still must note that the NAWQA sampling data, while considered high quality, are not targeted to sites and times where oxyfluorfen is used. Even regular sampling according to a predetermined schedule may not detect peak residues unless the samples happen to be taken shortly afterwards and adjacent to sites treated with oxyfluorfen. It seems likely, but may not be correct, that when samples are taken, the highest NAWQA residues may actually represent peaks that occur in natural waters.

Table 15. Oxyfluorfen Residues for Surface Water

State	# samples	% detects	max residue (ug/L)	# >1 ug/L
National	381	8.39 (32)	0.08370	0
California	53	37.74 (20)	0.01740	0
Oregon	36	55 (12)	0.08370	0
Washington	36	0	no detects	
Idaho	not sampled		no detects	

Targeted studies

Limited monitoring data provide further information for the evaluation of environmental risk to aquatic organisms. Based on sampling during February 1992 in the San Joaquin River, oxyfluorfen concentrations in water were estimated to be between 0.1 and 1.0 µg/L. Using 1.0 µg/L as an EEC, the Acute Risk LOC was exceeded for aquatic plants (RQ = 3.45) which was calculated using EC_{50} for algae , but there were no acute LOC exceedances for freshwater fish (RQ < 0.01)or invertebrates (RQ = 0.01) and estuarine fish (RQ < 0.01) or invertebrates (RQ = 0.03). Long term sampling at four sites had estimated average concentrations of oxyfluorfen in water ranging from 0.01 to 0.27µg/L, indicating a lower risk to aquatic organisms; however, localized high concentrations of oxyfluorfen have been observed.

As a result of the Goal 2XL spill in the Columbia River Basin (Fifteen Mile Creek) on August 24, 2000, focused sediment and water sampling was conducted. Water and sediment samples were collected as background measures from areas thought not to be impacted by the spill. The few background water samples did not have detectable amounts of oxyfluorfen, but 2 of the 35 background sediment samples did have detectible amounts of oxyfluorfen (the highest was 541 ppb). It is important to note that these background samples were collected seven months after most oxyfluorfen applications would have occurred (oxyfluorfen is primarily applied during the dormant winter season) (EPA 2000).

e. Water quality criteria

According to the RED chapter the proposed surface water-derived drinking water concentrations are 23.4µg/L for the 1 in 10 year annual peak concentration (acute) , 7.1 µg/L for the 1 in 10 year annual mean peak concentration (chronic) and 5.7 µg/L for the 36 year annual mean concentration.

f. Recent Changes in Pesticide Registrations

The Agency is in the process of developing more appropriate label statements for spray and dust drift control to ensure that public health, and the environment are protected from unreasonable adverse effects. In August 2001, EPA published draft guidance for label statements in a pesticide registration (PR) notice ("Draft PR Notice 2001-X"http://www.epa.gov/ PR_Notices/#2001). A *Federal Register* notice was published on August 22, 2001, 66 FR 44141 (http://www.epa.gov/fedrgstr) announcing the availability of this draft guidance for a 90-day public comment period. After receipt, and review of the comments, the Agency will publish final guidance in a PR notice for registrants to use when labeling their products.

Until EPA decides upon, and publishes the final label guidance for spray and dust drift, the registrant for oxyfluorfen has agreed to add the following spray drift related language, in part to address concerns of surface water runoff of oxyfluorfen (USEPA 2000).

- A 25 ft. vegetative buffer strip must be maintained between all areas treated with this product and lakes, reservoirs, rivers, permanent streams, marshes or natural ponds, estuaries and commercial fish farm ponds.

- Do not allow spray to drift from the application site and contact people, structures people occupy at any time and the associated property, parks and recreation areas, non-target crops, aquatic and wetland areas, woodlands, pastures, rangelands, or animals.

- For ground boom applications, apply with nozzle height no more than 4 feet above the ground or crop canopy and when wind speed is 10 mph or less at the application site as measured by an anemometer.

- Use coarse spray according to ASAE 572 definition for standard nozzles or VMD of 475 microns for spinning atomizer nozzles.

- The applicator also must use all other measures necessary to control drift.

g. Existing Protections

The current Goal 2XL (23% oxyfluorfen), a representative label, states in the environmental hazard section:

"Do not apply directly to water, to areas where surface water is present or intertidal areas below the mean high water mark. Do not contaminate water by cleaning of equipment or disposal of equipment washwaters. This product is highly toxic to aquatic invertebrates, aquatic plants, wildlife and fish. Use with care when applying in areas frequented by wildlife or adjacent to any body of water or wetland area. Do not apply when weather conditions favor drift or erosion from target areas. Runoff may be hazardous to aquatic organisms in neighboring areas."

Oxyfluorfen is also included in bulletins for California. There, the Department of Pesticide Regulation (DPR)in the California Environmental Protection Agency creates county bulletins consistent with those developed by OPP. However, California also has a system of County Agricultural Commissioners responsible for pesticide regulation, and all agricultural and commercial applicators must get a permit for the use of any restricted use pesticide and must report all pesticide use, restricted or not. The California bulletins for protecting endangered species have been in use for about 5 years. Although they are currently "voluntary " in nature, the Agricultural Commissioners strongly promote their use by pesticide applicators. Oxyfluorfen is currently included in these bulletins for the protection of non-target organisms (CDPR 2004). The specific limitations are:

- Do not use in currently occupied habitat except:
  (1) as specified in Habitat Descriptors
  (2) in organized habitat recovery programs
  (3) for selective control of invasive exotic plants.

- For sprayable or dust formulations: when the air is calm or moving away from habitat, commence applications on the side nearest the habitat and proceed away from the habitat. When air currents are moving toward habitat, do not make applications within 200 yards by air or 40 yards by ground upwind from occupied habitat. The county agricultural commissioner may reduce or waive buffer zones following a site inspection, if there is an adequate hedgerow, windbreak, riparian corridor, or other physical barrier that substantially reduces the probability of drift.

OPP currently has proposed (67 *Federal Register* 231, 71549-71561, December 2, 2002) a final implementation program that includes labeling products to require pesticide applicators to follow provisions in county bulletins. The comment period has closed, and a final *Federal Register* Notice is under development and is anticipated to be published in 2004. After this notice becomes final, it is expected that pesticide registrants will be required, as appropriate, to put on their products label statements mandating that applicators follow the label and county bulletins. It is also anticipated that these will be enforceable under FIFRA, including the California bulletins. Any measures necessary to protect T&E salmon and steelhead from oxyfluorfen would most likely be promulgated through this system.

h. Discussion and General Risk Conclusion for Oxyfluorfen

Based on toxicity studies with aquatic species submitted by the registrant, oxyfluorfen is "highly toxic" to fish exposed for short or extended periods of time, "very highly toxic" to "moderately toxic" to aquatic invertebrates exposed for short or extended periods of time, and "highly toxic" to aquatic plants when LOCs were calculated using an algal species (EPA 2000). The relative toxicity of oxyfluorfen is likely to lead to adverse effects in these organisms.

Table 16. Risk Quotients (RQ) for Freshwater Fish and Invertebrates and Aquatic Plants on Drift scenarios from EECs[1]

Almonds in California							
Type of Application	**Peak EEC (µg /L)**	**Acute Fish RQ**	**Acute invert RQ**	**21 Day EEC (µg /L)**	**Chronic invert RQ**	**60 Day EEC (µg /L)**	**Chronic Fish RQ**
Ground application No irrigation	10.24	0.051	0.130	6.19	0.310	4.63	0.125
Ground application with irrigation	6.10	0.030	0.080	3.80	0.190	2.78	0.080
Ground application No irrigation/No spray drift	9.81	0.049	0.123	5.80	0.290	4.21	0.114
Ground application with irrigation/No Spray drift	5.24	0.026	0.065	3.22	0.161	2.24	0.061
Aerial application No irrigation	12.82	0.064	0.160	8.36	0.418	6.56	0.177
Aerial application with irrigation	9.08	0.045	0.114	6.49	0.325	4.97	0.134
Aerial application No irrigation/No spray drift	9.41	0.047	0.117	5.57	0.279	4.04	0.109
Aerial application with irrigation/No spray drift	5.03	0.025	0.063	3.09	0.155	2.15	0.058

Grapes in California							
Type of Application	**Peak EEC (µg /L)**	**Acute Fish RQ**	**Acute invert RQ**	**21 Day EEC (µg /L)**	**Chronic invert RQ**	**60 Day EEC (µg /L)**	**Chronic Fish RQ**
Ground application No irrigation	3.900	0.020	0.049	2.672	0.13	2.331	0.063
Ground application with irrigation	1.103	0.006	0.014	0.868	0.04	0.749	0.020
Ground application No irrigation/No spray drift	3.560	0.018	0.040	2.319	0.12	1.981	0.054
Ground application with irrigation/No Spray drift	0.577	0.002	0.007	0.321	0.02	0.212	0.006
Aerial application No irrigation	5.980	0.030	0.075	5.053	0.25	4.441	0.120
Aerial application with irrigation	4.548	0.020	0.057	3.625	0.18	3.010	0.081
Aerial application No irrigation/No spray drift	3.416	0.017	0.043	2.226	0.11	1.902	0.051

Berries in Oregon

Type of Application	Peak EEC (µg /L)	Acute fish RQ	Acute invert RQ	21 Day EEC (µg /L)	Chronic invert RQ	60 Day EEC (µg /L)	Chronic fish RQ
Aerial application	2.961	0.015	0.040	2.337	0.117	2.025	0.055
Aerial application/ No spray drift	1.854	0.009	0.023	1.299	0.065	1.152	0.031
Ground application	2.110	0.011	0.026	1.495	0.075	1.358	0.038
Ground application/ No spray drift	1.932	0.010	0.241	1.353	0.068	1.201	0.032

Wheat in Oregon							
Type of Application	**Peak (µg /L)**	**Acute fish RQ**	**Acute invert RQ**	**21 Day (µg /L)**	**Chronic invert RQ**	**60 Day (µg /L)**	**Chronic fish RQ**
Aerial application	4.638	0.023	0.058	3.571	0.179	3.432	0.093
Aerial application/ No spray drift	3.738	0.019	0.047	2.744	0.137	2.603	0.070
Ground application	4.076	0.020	0.051	3.004	0.150	2.870	0.078
Ground application/ No spray drift	3.896	0.019	0.488	2.860	0.143	2.713	0.073

Mint in Oregon							
Type of Application	**Peak (µg /L)**	**Acute fish RQ**	**Acute invert RQ**	**21 Day (µg /L)**	**Chronic invert RQ**	**60 Day (µg /L)**	**Chronic fish RQ**
Ground application	10.305	0.052	0.129	7.568	0.379	6.969	0.188
Ground application/ No spray drift	9.587	0.048	0.120	6.807	0.341	6.314	0.171

[1] Based on fish LC_{50} (Bluegill sunfish) = 200 ppb; invertebrate LC_{50} (waterflea) = 80 ppb; chronic invertebrate NOEC (waterflea) = 20 ppb; chronic fish NOEC (Rainbow trout) = 37 ppb. Acute RQ = peak EEC/LC_{50}; chronic invertebrate RQ = 21-day EEC/invertebrate NOEC; chronic fish RQ = 60-day EEC/chronic fish NOEC Application rates are listed in EEC attachment.

With a most sensitive fish LC_{50} of 200 ppb, the LOCs for direct acute effects for endangered species would be exceeded when oxyfluorfen concentrations in water exceed 10.00 ppb [RQ for direct effects to endangered species = concentration of oxyfluorfen/ LD_{50} of most sensitive fish]0.05 = concentration of oxyfluorfen/200 ppb) . The concern for chronic risk is demonstrated in the requested EECs on the fish, with a NOEL of 37 ppb, and chronic exposure is likely for oxyfluorfen.

In the RED chapter, the preliminary risk assessment for endangered species indicated exceedances for the endangered species LOCs for the freshwater fish for non-bearing citrus and grapes scenarios. Exceedances for the EECs specific for the pacific northwest region and California LOC's for acute and chronic risks are listed in table18.

Table 17. Risk-quotient criteria for fish and aquatic invertebrates

Test data	Risk quotient	Presumption
Acute LC50	>0.5	Potentially high acute risk
Acute LC50	>0.1	Risk that may be mitigated through restricted use classification
Acute LC50	>0.05	Endangered species may be affected acutely, including sublethal effects
Chronic NOEC	>1	Chronic risk; endangered species may be affected chronically, including reproduction and effects on progeny
Acute invertebrate LC50	>0.5	May be indirect effects on T&E fish through food supply reduction
Aquatic plant acute EC50	>1.0	May be indirect effects on aquatic vegetative cover for T&E fish

Table 18. RQ Exceedances for Modeled Scenarios

Almonds in California						
	Acute LC_{50} RQ exceeded			**Chronic NOEC RQ exceeded**	**Indirect Acute LC_{50}/ EC_{50} RQ exceeded**	
	>0.5	>0.1	>0.05	>1.0	>0.5 invertebrates	>1.0 plants
Application						
Ground application No irrigation	no	no	**yes**	no	no	N.C.
Ground application with irrigation	no	no	no	no	no	N.C.
Ground application No irrigation/No spray drift	no	no	no	no	no	N.C.
Ground application with irrigation/No Spray drift	no	no	no	no	no	N.C.
Aerial application No irrigation	no	no	**yes**	no	no	N.C.
Aerial application with irrigation	no	no	no	no	no	N.C.
Aerial application No irrigation/No spray drift	no	no	no	no	no	N.C.
Aerial application with irrigation/No spray drift	no	no	no	no	no	N.C.

Grapes in California						
	Acute LC_{50} RQ exceeded			**Chronic NOEC RQ exceeded**	**Indirect Acute LC_{50}/ EC_{50} RQ exceeded**	
	>0.5	>0.1	>0.05	>1.0	>0.5 invertebrates	>1.0 plants
Application						
Ground application No irrigation	no	no	no	no	no	N.C.
Ground application with irrigation	no	no	no	no	no	N.C.
Ground application No irrigation/No spray drift	no	no	no	no	no	N.C.
Ground application with irrigation/No Spray drift	no	no	no	no	no	N.C.
Aerial application No irrigation	no	no	no	no	no	N.C.
Aerial application with irrigation	no	no	no	no	no	N.C.
Aerial application No irrigation/No spray drift	no	no	no	no	no	N.C.

Berries in Oregon						
	Acute LC_{50} RQ exceeded			**Chronic NOEC RQ exceeded**	**Indirect Acute LC_{50}/ EC_{50} RQ exceeded**	
	>0.5	>0.1	>0.05	>1.0	>0.5 invertebrates	>1.0 plants
Application						
Aerial Application	no	no	no	no	no	N.C.
Aerial application/ No spray drift	no	no	no	no	no	N.C.
Ground application	no	no	no	no	no	N.C.
Ground application/ No spray drift	no	no	no	no	no	N.C.

Wheat in Oregon						
	Acute LC_{50} RQ exceeded			**Chronic NOEC RQ exceeded**	**Indirect Acute LC_{50}/ EC_{50} RQ exceeded**	
	>0.5	**>0.1**	**>0.05**	**>1.0**	**>0.5 invertebrates**	**>1.0 plants**
Aerial application	no	no	no	no	no	N.C.
Aerial application/ No spray drift	no	no	no	no	no	N.C.
Ground application	no	no	no	no	no	N.C.
Ground application/ No spray drift	no	no	no	no	no	N.C.

Mint in Oregon			
	Acute LC_{50} RQ exceeded	**Chronic**	**Indirect Acute LC_{50}/ EC_{50} RQ exceeded**

				NOEC RQ exceeded		
	>0.5	>0.1	>0.05	>1.0	>0.5 invertebrates	>1.0 plants
Ground application	no	no	**yes**	no	no	N.C.
Ground application/ No spray drift	no	no	no	no	no	N.C.

N.C.: RQs for aquatic plants were not calculated due to lack of toxicity data on vascular aquatic plants**.** Lemna are the species of choice for calculation of risk to aquatic vegetation to be used as cover for freshwater organisms. Although the RED uses algal species in its assessment the use of that species is not appropriate for this assessment.

Oxyfluorfen is highly toxic to fish and very highly toxic to invertebrates. Acute LOC's were only slightly exceeded for endangered and threatened freshwater fish for ground and aerial applications without irrigation to almonds in the California model and mint for ground applications in the Oregon model. The charts show LOC's were not exceeded for chronic risk to endangered species including reproduction and effects on progeny for ground applications to almonds, aerial applications to grapes and ground applications to mint.

Conclusions

The EEC is intended to determine the maximum potential risk that may occur from the use of Oxyfluorfen. Therefore, it can be expected that any site-specific or species-specific analysis is likely to determine that risks are less than the maximum potential. In part, this is reflected in the western EEC scenarios, which are modified by less runoff and somewhat higher drift than eastern scenarios.

Oxyfluorfen poses a threat to aquatic organisms through spray drift of liquid formulations and runoff of dissolved and soil entrained oxyfluorfen. In addition, the potential of oxyfluorfen (as a light-dependent peroxidizing herbicide) to be more toxic in the presence of intense light may lead to the occurrence of environmental effects that are not predicted by standard guideline toxicity tests (US EPA 2001). However, EEC's are based on the maximum use rates described on the label. Therefore the exposure of aquatic organisms may be less than that estimated.

Except for the photolysis, in water study (which indicates relatively rapid degradation), laboratory data indicate that oxyfluorfen is persistent in soil: aerobic soil metabolism half-lives of 291 and 294 days in a clay loam soil and 556 and 596 days in a sandy loam soil; and anaerobic soil metabolism half-lives between 554 and 603 days. Adsorption/desorption studies suggest oxyfluorfen is relatively immobile, except perhaps when used on very sandy soils. The most likely route of dissipation is soil binding. Laboratory data suggest that once the soil-bound oxyfluorfen reaches deep or turbid surface water it will persist since it is stable to hydrolysis and since light penetration would be limited; however, it may degrade by photolysis in clear, shallow water. Oxyfluorfen can contaminate surface water through spray drift and runoff; however, it is unlikely to contaminate ground water because it is relatively immobile in the soil column; therefore, the likelihood of leaching is small (USEPA 2000).

The levels of concern for endangered and threatened fish were only slightly exceeded (0.064, 0.052 and 0.051) in the highly conservative models performed on a multitude of application procedures on major crops. Furthermore, oxyfluorfen is not state registered for aerial application in Washington State or California which would preclude one of the exceedences. Salmon and steelhead occur in large rapidly moving rivers where the concentration of oxyfluorfen is likely to be significantly less than that estimated in the model. Because the EECs were calculated using the highest application rates at the shortest application interval, they illustrate concentrations that may be much higher than what is seen in the field. In considering all of the variables outlined in this analysis it is my professional opinion that oxyfluorfen will have no effect on the ESUs of Pacific salmon and steelhead. The data also indicate that the levels of concern for risks to aquatic invertebrates and plants were not exceeded for any crop scenario. Therefore there is also no indirect effects on threatened and endangered salmonids form loss of food supply or loss of cover.

4. Specific Conclusions for Pacific Salmon and Steelhead

Table 19. Summary Conclusions on Specific ESUs of Salmon and Steelhead for Oxyfluorfen

Species	ESU	Finding
Chinook Salmon	California Coastal	no effect
Chinook Salmon	Central Valley spring-run	no effect
Chinook Salmon	Lower Columbia	no effect
Chinook Salmon	Puget Sound	no effect
Chinook Salmon	Sacramento River winter-run	no effect
Chinook Salmon	Snake River fall-run	no effect
Chinook Salmon	Snake River spring/summer-run	no effect
Chinook Salmon	Upper Columbia spring-run	no effect
Chinook Salmon	Upper Willamette	no effect
Chum salmon	Columbia River	no effect
Chum salmon	Hood Canal summer-run	no effect
Coho salmon	Central California	no effect
Coho salmon	Oregon Coast	no effect
Coho salmon	Southern Oregon/Northern California Coast	no effect
Sockeye salmon	Ozette Lake	no effect

Sockeye salmon	Snake River	no effect
Steelhead	Central California Coast	no effect
Steelhead	Central Valley, California	no effect
Steelhead	Lower Columbia River	no effect
Steelhead	Middle Columbia River	no effect
Steelhead	Northern California	no effect
Steelhead	Snake River Basin	no effect
Steelhead	South-Central California	no effect
Steelhead	Southern California	no effect
Steelhead	Upper Columbia River	no effect
Steelhead	Upper Willamette River	no effect

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