# PROPOSED SURFACE WATER CRITERIA FOR SELECTED PESTICIDES USED FOR FOREST MANAGEMENT AND MANAGEMENT OF FOREST TREE SEEDLING NURSERIES AND CHRISTMAS TREE PLANTATIONS IN OREGON AND WASHINGTON

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TIMBER/FISH
&WILDLIFE

AUGUST 20, 1992

Proposed

# Surface Water Quality Criteria for Selected Pesticides Used for Forest Management and Management of Forest Tree Seedling Nurseries and Christmas Tree Plantations In Oregon and Washington

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## INTRODUCTION

Surface water quality standards for pesticides used in forestry are needed to (1) permit evaluation of the effect of pesticide use on aquatic organisms and on humans and animals which consume water from forest areas, (2) determine the effectiveness of strategies used to protect water quality, and (3) provide a basis for evaluating adherence to regulatory rules which govern the use of pesticides in forestry in Washington and Oregon. The purpose of this report is to provide surface water quality criteria which provides the basis for selecting standards to meet these goals. This effort was undertaken at the request of The Oregon Department of Forestry and The Washington Department of Natural Resources. The report has been extensively reviewed and revised in response to reviewer's comments.[3]

Water quality standards for forest pesticides are usually developed to assure protection of human health and prevent adverse toxic effects on aquatic organisms, or terrestrial animals which may reside in or consume the water. This report identifies concentrations (criteria) of specific pesticides in

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[3]We gratefully acknowledge the detailed reviews and helpful suggestions from Mr. Ed Rashin, Washington Department of Ecology, Olympia, Washington. This report is significantly enhanced because of his help.

surface water which will achieve these goals in connection with the following two broad patterns of pesticide use:

(aT forest management, and
(b) forest seeding nursery and Christmas tree plantation management.

These criteria in turn can provide a basis for establishment of water quality standards.

## GENERAL APPROACH

### Identifying Critical Exposure and Toxicity Values

Based on literature, we identified critical exposure levels of specific pesticides which we feel will not result in adverse toxic effects, This exposure level (with an added margin of safety to provide for uncertainties and variations in sensitivity) is expressed as parts per million, i.e., ppm or mg/liter, in water.

These criteria were developed differently for humans and aquatic animals. Aquatic plants are not included. The exposure in toxicity testing with mammalian species is usually expressed as mg of chemical per kg of body weight of the animal for some defined period of time such as each day, or mg/kg/day. In general, we identified the EPA ]O-day or lifetime exposure Health Advisory, the World Health Organization (WHO) Allowable Daily Intake (ADI) value, or when these values were not identified, we developed an exposure level we feel reflects the strategies used in deriving the EPA or WHO values.

We assume that preventing adverse effects in humans will also prevent adverse effects in other mammals. The reason is that human criteria are derived from testing done on other animals, and is usually based on the lowest identifiable no-observable-effect-level in any of the commonly used test animals. In addition, the safety factor used to assure human protection at the individual level, is more conservative than needed to protect other animals at the population level.

The exposure in aquatic species toxicity testing is usually expressed as the concentration (ppm or mg/liter) of a specific pesticide in the water. In general, we identified the lowest identifiable median tolerance limit (usually for cold-water invertebrate and fish species) and then applied safety factors to identify the concentration below which we believe adverse effects will not Occur,

### Adjusting Criteria for Different Patterns of Forestry Pesticide Use

There is an extensive base of data on water monitoring following applications of herbicides and insecticides for forest management. These data provide information about the concentrations of specific pesticides to be expected in surface water after applications by various methods. These data are helpful in evaluating potential exposure, and therefore adverse impacts. For forest management pesticide uses, we used a ]O-day exposure scenario for humans and a 24-hour exposure for aquatic organisms.

No information on patterns of water contamination has been developed for pesticide uses in forest nurseries, and there is very little data available that applies to management of Christmas tree plantations. Thus, there is only a poorly defined basis for estimating exposure. Because of this uncertainty, we assume intermittent, but prolonged exposure for nursery and Christmas tree management operations.

Thus, we identify different recommended water quality criteria depending on the pattern of use, i.e., (a) forest management or (b) nursery and Christmas tree operations. Particularly we have added an additional five-fold safety factor for pesticide use in nurseries and Christmas tree plantations. These strategies are explained in more detail in sections ! and 2 of this report.

We feel the forest management guidelines are likely sufficient for nursery and Christmas tree management, but in the face of uncertainty about actual patterns of water contamination, we have used this health conservative strategy. We emphasize the nursery and Christmas tree criteria are temporary guidelines. Water quality monitoring data is needed. When it is available, we strongly urge re-evaluation of the criteria to assure that they are effective in preventing adverse effects, but are not unnecessarily restrictive.

Cancer, Inert Ingredients, Metabolites, Multiple Pesticide Exposures and Related Issues

Cancer: This report does not determine risks of carcinogenic response. Of the forestry pesticides included in this report, a few are equivocally carcinogenic, and those are of very low potency. Our assumption is that exceedance of the water quality criteria we recommend will almost certainly be of short duration, and at levels that would provide a minuscule dose in terms of carcinogenic effect. Others have gone through this exercise and it is quite clear that such risk cannot be practically differentiated from zero (Shipp, et al. 1986). If necessary, carcinogenic risk estimates can be developed but we judge this unnecessary.

Inert Ingredients: Questions have been raised about the significance of inert ingredients, degradation products and the presence of other pesticides as contributors to the potential impacts for the use of pesticides in forestry. Until recently the identity of most "inert" materials has been held as trade secret information by manufacturers (inert ingredients are defined as those substances added purposely to formulations as diluents, adjutants, preservatives and so on, but without pesticidal activity.)

Because some inert ingredients actually have significant toxicity, the USDA Forest Service, Region 8 and later Region 5 have obtained identification of the inert ingredients in forest pesticide formulations. The only inert ingredient of toxicological significance in this group are kerosene and diesel fuel used as a diluent in some formulations. Public concern has been expressed about the surfactant in Roundup formulation of glyphosate. It does not represent a hazard to mammals. The surfactant in Roundup is more toxic to fish than the glyphosate itself, but we relied on toxicity testing done with the formulated material.

Metabolites: Only one pesticide included in our report (acephate) degrades to a product with toxicity equal to or greater than that of the parent. Approximately 5-10% forms metamidophos, but the rate of formation is slow enough that significant amounts do not accumulate. For a degradation product to contribute to the toxicity of a pesticide, it must be as or more toxic than the parent, and it must form rapidly enough or be stable enough that.amounts found in the environment represent a considerable fraction of the amount of parent compound. None of the pesticides reported here meet that requirement. Aminomethyl phosphoric acid, a metabolite of glyphosate, is as limited in its toxicity as glyphosate and is found only because it is sufficiently stable and immobile enough, to remain in place as glyphosate degrades.

Multiple Pesticide Exoosures: The collective effect of multiple pesticide exposure has been studied to a very limited extent. The reasons are obvious; if one considers just the herbicides in the list we are dealing with, and an arbitrary number of 10 kinds of tests, the number Of combinations becomes staggering. More importantly, it is not necessary to conduct such an array of assays, because enough work has been done on combinations of pharmaceutical agents to demonstrate some principles from which sound predictions of effects of pesticide combinations can be made. Therapeutic drugs are given in very large doses compared to even the most extensive intakes of pesticides, and it is clear that responses in combination are dose responsive and threshold-based. The doses required are also large relative to pesticide exposures.

Synergistic or Antagonistic Effects: Chemicals can alter the responses to other chemicals by a limited number, of mechanisms. Most frequently, absorption, metabolism or excretion of one agent might be changed by another; in such cases the mechanisms of action of the two are not usually biochemically related. If one chemical acts at the same site as another the two effects may either augment or antagonize one another. Occasionally, there may be a two step process in which one agent acts on one step and the other acts on the next part of the sequence.. In none of these scenarios do responses occur at the very low doses that can occur with consumption of water derived from areas used for forest management, and we believe from forest nursery or Christmas tree plantations.

Routes of Human Exposure: Our assignment was to develop recommendations for water quality criteria. However, there are other potential routes of human exposure besides drinking water. For forest management uses we feel research and operational experience show exposure via drinking water will be infrequent and transitory. Because of the conservative strategies we incorporated, we feel the entire dose for these brief periods of exposure can come from water. Thus, we have ignored other potential routes of exposure for the forest management chemical use patterns. Other exposure scenarios are possible (Weeks et al. 1988) but we feel these seriously over estimate exposure because they maximize all possible routes of exposure simultaneously.

For nursery and Christmas tree uses, we took a different approach. Because of uncertainties about patterns of exposure from these uses, we used a lifetime exposure scenario and included an additional five-fold safety factor to reflect EPA's assumption that drinking water is 20% of the total possible dose.

This report is in three major sections. Section 1 deals with protection of human health and section 2 focuses on protection of freshwater aquatic organisms, Section 3 combines information from Sections 1 and 2 to identify potential water quality criteria which we feel will protect humans, aquatic organisms, and other animals with appropriate adjustments to reflect patterns of use.

## SECTION 1. PROTECTING HUMAN HEALTH

For protection of humans, any water quality standard must. take into account potential consumption of water from the affected source, and the expected potential impact on each individual who may use the source. The generally accepted approach in protecting human health is to (1) establish a water. quality standard based on an intake level or dose of the chemical that can be expected (with a high degree of confidence)to produce no effect, and (2) assure through regulation and management, that such a dose is not exceeded.

The dose is derived from experimental toxicological data (usually the most sensitive experiments demonstrating a no-observed-effect level [NOEL]). Depending on the quality of the data, a margin of safety is usually included so the intake level (or dose) allowed by the standard is 100- to 1000-fold lower than the NOEL.

In this section of. the report we identify the concentrations of specific pesticides in water that we believe will not cause adverse human health effects. We call these water quality criteria. They are derived differently depending on the patterns of use. For forest management pesticide uses, these criteria are derived from the EPA ]O-day Exposure Health Advisories, or if not available, we developed values using the same strategies from ADI or NOEL values.

For pesticides used in forest nursery or Christmas tree operation, we used Lifetime Allowable Daily Intakes (ADI) recommended by the EPA or the World Health Organization, or if not available, we derived a value using the same strategy from the NOEL. We further reduced the nursery and Christmas tree use values by a factor of five to reflect EPA's assumption that 20% of the dose may be by ingestion of drinking water.

For this analysis we used ingestion of contaminated water as the route of exposure and children as the subject of exposure. We assume children are more sensitive than adults, and that children weigh ]0 kg (22 pounds) and consume one liter of water daily. We use the child as the exposure subject, even in the nursery and Christmas tree pesticide use pattern analysis, even though in a lifetime exposure the subject is adult through most of that period. The difference is a factor of seven, and when combined with the five-fold reduction for rate of exposure may be overly conservative.

2,4-D, 2,4-DP and triclopyr esters and amines are not differentiated in the recommendations on human standards because the various forms hydrolyze quickly to the parent acid in the body fluids, and the toxicological pattern is similar within each group.

The EPA Health Advisories are produced by the EPA Office of Drinking Water, and identify one-day, ten-day, longer term and lifetime exposure levels below which no adverse effect is expected, In most cases, EPA did not set a one-day exposure level, and used the more conservative ten-day estimate as a substitute for the one-day exposure period. The following is introductory material for all EPA Advisories; We include it because the health advisories are central to our analysis.

"The Health Advisory (HA) Program, sponsored by the Office of Drinking Water {ODW}, provides information on the health effects, analytical methodology and treatment technology that would be useful in dealing with the contamination of drinking water. Health Advisories describe nonregulatory concentrations of drinking water contaminants at which adverse health effects would not be anticipated to occur over specific exposure durations. Health Advisories contain a margin of safety to protect sensitive members of the population.

Health Advisories serve as informal technical guidance to assist Federal, State and local officials responsible for protecting public health when emergency spills or contamination situations occur. They are not to be construed as legally enforceable Federal standards. The HAs are subject to change as new information becomes available.

Health Advisories are developed for one-day, ten-day, longer-term {approximately 7 years, or ]0% of an individual's lifetime) and lifetime exposures based on data describing noncarcinogenic end points of toxicity. For those substances that are known or probable human carcinogens, according to the Agency classification scheme (Group A or B), Lifetime HAs are not recommended. The chemical concentration values for Group A or B carcinogens are correlated.with carcinogeni.c risk estimates by employing a cancer potency (unit risk} value together with assumptions for lifetime exposure and the consumption of drinking water. The cancer unit risk is usually derived form the linear multistage model with 95% Upper confidence limits. This provides a low-dose estimate of cancer risk to humans that is considered Unlikely to pose a carcinogenic risk in excess of the stated values. Excess cancer risk estimates may also be calculated using the one-hit, Weibull, logit or probit models. There is no current understanding of the biological mechanisms involved in cancer to suggest that any one of these models is able to predict risk more accurately than another. Because each model is based on differing assumptions, the estimates that are derived can differ by several orders of magnitude."

Table I provides human health protection criteria for forest management. Table 2 does the same for nursery and Christmas tree uses.

The following text provides more detail about these values for specific chemicals. All incorporate safety factors and uncertainty estimates to indicate a daily intake that should not be exceeded but can be expected with high confidence to produce no harm. Findings which exceed these levels should trigger careful evaluation of procedures which produced them to avoid reoccurrence. Finding one of the pesticides identified in this report at the advisory level suggested in this report should not be interpreted as representing a health threat.

Table 1. Forest management: Surface water quality advisory criteria which will provide protection of human health.

| Pesticide | EPA lO-day Health Advisory Criteria | NOEL or ADI Derived Criteria[1] |
|---|---|---|
| | --mg/liter .... | mg/liter-- |
| Asulam | --- | 1.0 |
| Atrazine | 0.! | --- |
| BT | No useful data available | |
| Carbaryl | 1.0 | --- |
| Dalapon | 2.7 | ~-- |
| Dicamba | 0.3 | --- |
| Diesel | --- | 0.700 |
| 2,4-D (All form.)[Z] | 0.3 | --- |
| Fosamine | 2.0 | --- |
| Glyphosate | 17.5 | --- |
| Hexazinone | 2.5 (90 day) | --- |
| Imazapyr | --- | 10.0 |
| Picloram | 20.0 | --- |
| Simazine | 0.5 | --- |
| Sulfometuron methyl | --- | 0.1 |
| Triclopy | --- | 0.25 |

EPA has not identified a 10-day water quality Health Advisory level for chemicals with values listed in this column. Some values are derived from EPA or World Health Organization (WHO) acceptable daily intake (ADI} recommendations. See following section for derivation of these values.

Includes ester and amine forms, and 2,4-DP. The EPA criteria for 2,4-DP in domestic water supply is 0.1 mg/liter. We do not use this value because we feel the 10-day health advisory more accurately reflects potential patterns of exposure in forest use of 2,4-D and 2,4-DP.

Includes amine and ester forms.

Table 2. Forest tree seeding nursery and Christmas tree plantation management: Surface water quality advisory criteria which will provide protection of human health.’

| Pesticide | EPA Lifetime Health Advisory Criteria | NOEL or ADI Derived Criteria[2] |
|---|---|---|
| | --mg/liter .... | mg/liter-- |
| Acephate | --- | 0.001 |
| Amitrole | --- | 0.0004 |
| Asulam | --- | 0.2 |
| Atraztne | 0.003’ | --- |
| Bifenthrin | --- | 0.1 |
| Chlorothalonil | --- | 0.01 |
| Diesel | --- | 0.14 |
| Dienochlor | Data not available | |
| Endosulfan[4] | --- | 0.02 |
| Hexazinone | 0.2 (90 day) | --- |
| Mancozeb | --- | 0.006 |
| Propargite | --- | 0.2 |
| Simazine | 0.0035 | --- |

The values in this table incorporate an additional five-fold safety factor to allow for uncertainty about patterns of exposure by water consumption in connection with the use of these pesticides in nursery and Christmas tree operations.

EPA has not identified a 10-day water quality Health Advisory level for chemicals with values listed in this column. Some values are derived from EPA or World Health Organization (WHO) acceptable daily intake (ADI) recommendations.

Value based on 0.00! LCso, see text.

Endosulfan and metabolites.

## Acephate (Orthene)

Acephate has been reviewed by the World Health Organization and FDA, as well as by the OSU Extension Toxicology Program in connection with the effort to eradicate a Gypsy Moth infestation in Lane County, Oregon. It is an acetylcholine esterase (AChase) inhibitor, and in lifetime.studies produces such inhibition at doses that do not cause other forms of toxicity. Because AChase inhibition does not reverse quickly, intake at rates greater than the recovery rate could cause cumulative effects.

FAO-WHO have published a recommended allowable daily intake of 0.0005 mg/kg/day (FAO, 1984). Subsequently, FAO-WHO have published ADIOs of 0.003 mg/kg/day in 1986 and 0.03 mg/kg/day in 1988. The differences seem to be abased on better understanding of the data and are valid. Nevertheless, we would suggest the most conservative position, given the absence of a clear understanding of use rates and potential for water contamination in nursery use.

If water were the only source of exposure, the ADI of 0.0005 mg/kg/day represents a concentration of 0.005 ppm (mg/liter). Water, however, is assumed to represent 20% of the exposure, which we have further reduced five-fold leaving 0.001 ppm as the suggested criterion for nursery and Christmas tree uses.

## Amitrole

The most important toxic effect of amitrole is decreased thyroid function and consequent hyperplasia of the thyroid. A NOEL of 25 mg/kg day for 119 days has been noted, but a lower NOEL for amitrole in water of 0.5 mg/kg/day is used as the basis for this standard. We recommend a 500 fold safety factor because of the variability in the data, providing a reference dose of 0.001 mg/kg day. Water is assumed to contribute 20% of the total exposure, which makes the daily dose from water, 0.0002 mg/kg/day or 0.002 mg/day for a 10 kg child. Incorporating the additional five-fold safety factor convention for nursery and Christmas tree uses which we use throughout this report, we recommend a water quality criterion of 0.0004 ppm (mg/liter). In our opinion, amitrole use should be confined to very special cases, with applicators particularly well informed about the characteristics of this chemical. Amitrole toxicology is summarized in USDA Forest Service (1984).

## Asulam

Asulam has limited mammalian toxicity. Asulam appears to have no genetic or carcinogenic effects, although the latest data available to us indicates that one carcinogenicity study is not acceptable because the test substance was not properly identified, and there were problems with general health of the animals. The most sensitive valid finding was thyroid hyperplasia in rats, for which the NOEL was 36 mg/kg/day, which is the basis for this recommendation (EPA 1988). For this standard, the rabbit teratogenicity NOEL of 40 mg/kg/day will be used as a basis. A 100 fold safety factor plus a four-fold multiplier for some uncertainty of data suggests an acceptable standard of 0.! mg/kg/day. For a 10 kg child consuming one liter per day, this represents a water criterion of 1.0 ppm {mg/literi for forest management. For nursery and Christmas tree uses, where the lifetime exposure scenario is used, the criterion is 0.2 ppm.

Bifenthrin

There is very little specific data available on bifenthrin. Data available indicates it is not genotoxic, and the class of chemicals which includes bifenthrin shows little evidence of carcinogenicity. Bifenthrin is not teratogenic and is eliminated rapidly by mammals. Based on acute toxicity (LCso 54.5 mg/kg) and the apparent absence of cumulative activity, we believe a provisional water quality criteria that provides a lO00-fold lower dose {0.05 mg/kg) will be fully protective. The concentration in water which will not exceed this dosage level for a lO-kg child is 0.5 mg/liter, which we reduce to 0.1 mg/liter for nursery and Christmas tree uses because water is estimated to be 20% of the total exposure.

Chlorothalonil (Bravo, Daconil)

Absorption across body surfaces is limited, tissue residues are low after high doses, and excretion is complete in a few days. The most important effect for applicators is contact dermatitis and sensitization and reversible eye irritation. Chlorothalonil is probably carcinogenic, causing some renal tubular adenomas and carcinomas in rats at high doses and non-dose related forestomach tumors in mice. The systemic NOEL for most chronic assays is between 1.5 and 3 mg/kg/day, with various relatively non-specific findings.

EPA uses a Health Advisory of 0.2 ppm, rounded up from 0.15 ppm. WHO has set a temporary ADI of 0.005 mg/kg/day, which incorporates a safety factor of 300 from the NOEL of 1.5 mg/kg/day. At a consumption of one liter of water per day, that dose would be met by a criterion of 0.05 ppm (mg/liter), which we further reduce to 0.01 mg/liter in connection with nursery and Christmas tree uses. See FAO (1987) for extensive discussion of chlorothalonil toxicology.

Diesel

It is difficult to derive specific human health criteria related to residues in surface water. The usual concerns with diesel are for occupational exposure and workers directly in contact with the material. Host studies are directed to dermal and pulmonary exposure.

Acute oral toxicities of diesel fuel and kerosene are limited. The median lethal doses are about 7000 mg/kg for diesel, and higher for kerosene. None of these studies permits derivation of a NOEL. There are numerous studies of the various major components of diesel fuel and kerosene, and all indicate low toxicity, but the proportions are variable. Consequently, toxicity estimates must be qualitative. The primary effects of all components of these mixtures in animal studies and evaluation of exposed human populations indicates that the most important effects are irritation at the sites of contact and central nervous depression at high concentrations, and kidney injury with very high exposures.

Diesel and kerosene have been administered by inhalation, for evaluation of teratogenic effects. This is not an applicable route for considering intakes due to water contamination, because surface irritant effects on the lung contribute to the response. In those studies, however, there were considered to be no effects of either mixture at air concentrations of 400 ppm, although food consumption decreased at that level. Detailed pathology was not done, except on the fetuses. (There is some confusion of nomenclature; in this context ppm usually means mg/cubic meter, which is technically incorrect. Such terminology should only. apply to volume/volume or weight/weight ratios.)

A concentration of 400 mg/cubic meter, at a ventilation rate of about 700 ml of air/kg/minute for the rat provides an intake of 0.28 mg/kg/min., or about 400 gm/kg/day, assuming 100% absorption from the lung.

Lacking data for either acute or subacute NOELs by oral administration, we may assume that the acute NOEL is 0.01LCso or 70 mg/kg, which is a reasonable, although conservative figure based on other chemicals. Given the crudity of the comparison, this is not inconsistent with the NOEL of 400 mg/kg suggested by the inhalation data. A longer term NOEL would then be 7 mg/kg/day. The array of data on constituents does not constitute a full spectrum of toxicologic analysis, but the consistency of the existing findings suggests that a safety factor of 100 is sufficient for setting a water quality criteria. The permissible longer term dose for a 10 kg child consuming a liter of water a day would be 0.07 mg/kg/day. The corresponding water concentration would be 0.7 mg/liter in forest management uses, and with a 20% factor for lifetime exposure, the criterion is 0.14 ppm (mg/liter) for nursery and Christmas tree uses.

These figures may be compared with the theoretical concentration that would result from direct application of 10 gallons of diesel per acre of water one foot deep, 2.6 ppm (2.6 q/liter), or about four times the forest management criterion. See Weeks et al. (1988b) and U.S. Air Force (1989) for more details.

Endosulfan (Thiodan)

Endosulfan has been reviewed by WHO-FAO, and a temporary lifetime.ADI of 0.008 mg/kg/day is recommended. It is a chlorinated cyclodiene hydrocarbon, but is rapidly excreted. The toxicological data base is extensive, and the compound is interesting in that almost all NOELs are somewhat below one mg/kg/day, in a variety of species, study durations and effects. The NOEL used is 0.75 mg/kg/day, which, with a 100 fold safety factor, leads to the Allowable Daily Intake of 0.008 mg/kg/day. For a 10 kg child the total dose NOEL is 0.08 mg/day, which is represented by consumption of one liter of water per day at a concentration 0.08 ppm (mg/liter), which is further reduced by a factor of five for nursery and Christmas tree uses (WHO 1984, 1989).

Imazapyr

Our data for Imazapyr (Arsenal formulation) is incomplete. Imazapyr is neither carcinogenic or mutagenic. The NOEL for teratogenic effect in rats is

1000 mg/kg/day, with modest maternal toxicity. The teratogenic NOEL for rabbits is 400 mg/kg/day. Excretion half time is about one day. On the basis of the rabbit NOEL of 400 mg/kg/day and with 30 and 90 day general toxicity studies not presently available to us, a standard based on a tentative reference dose of one mg/kg/day is recommended. This dose rate is based on a standard 100 fold safety factor, with a multiplier of 4X to accommodate unavailable data. For a 10 kg child, the total dose would be 10 mg/day, or ]0 ppm (mg/liter) in water.

Mancozeb (Dithane, Manzate)

This fungicide is an ethylene bisdithiocarbamate, and registration of all members of this class is currently under question, particularly on food crops. They metabolize to ethylene thiourea, which is carcinogenic and thyroid active. The data base is considered inadequate. The EBDCs have some leaching potential, although data are sketchy. In forest tree seeding nurseries this may be a concern. Long term systemic effects in the dog appear most sensitive, with a NOEL of 3,0 mg/kg/day. The provisional EPA ADI is 0.003 mg/kg/day, based on the two year NOEL in dogs noted above with a 1000 fold safety factor because of the significant data gaps. The allowable total dose for a 10 kg child is then 0.03 mg per day. At a water intake of one liter per day, that level represents a concentration of 0.03 mg/liter or ppm, which we further reduce by five-fold to allow for nursery and Christmas tree uses to give a criterion of 0.006 ppm (mg/liter) (EPA I987).

Propargite (Omite)

Propargite is extensively metabolized, with small amounts detectable in milk and fat of cattle but not in other tissues. Acute toxicity is low. Fetal toxicity and teratogenicity are limited but some skeletal anomalies were seen at 25 mg/kg/day. FAO has judged the NOEL at 15 mg/kg/day. Propargite appears not to be carcinogenic, but only one species has been evaluated. Primary data is proprietary. EPA has set an Allowable Daily Intake at 0.225 mg/kg/day and FAO uses a figure of 0.08 mg/kg/day on a temporary basis. In setting the FAO figure, a gO0 fold safety factor was used. For a 10 kg child, the total one day allowable dose based on the FAO allowable lifetime dose per day would be 0.8 mg. If water consumption is one liter per day, allowable concentration is 0.8. mg/liter (ppm). As a nursery or Christmas tree chemical we have divided this figure by five and rounded to 0.2 ppm (mg/liter) (FAO 1978).

Sulfometuron methyl (Oust)

The toxicity of sulfometuron methyl is summarized in USDA Forest Service (1987), on the basis of technical data sheets provided by the registrant. The one year systemic effect NOEL for the dog is § mg/kg/day, and in a two generation rat study extending over two years, the systemic NOEL is 2.5 mg/kg/day. Other NOELs are higher. Based on the findings for the dog, a single dose of 0.01 mg/kg or 0.1 mg total dose for a 10 kg child consuming one liter of water per day provides a safety factor of 500; a water quality criterion of 0.1 ppm (mg/liter) provides this factor.

lriclopyr

Data on triclopyr is extensive. General toxicity studies up to gO days indicate NOELs of from 20 to 30 mg/kg/day. A long term study,in the rat indicated minor changes in the rat kidney at lower doses, with a NOEL of $ mg/kg/day. Studies in the dog over a six-month period show a slight decrease in ability to excrete organic acids at exposures of 2.5 mg/kg/day, but the dog is unique among mammals in having poor capacity for excretion of organic acids and is therefore an inappropriate test subject for triclopyr. Nonetheless, the findings in the dog study are used here to modify the NOEL as a health conservative strategy. At 2.5 mg/kg/day, with a safety factor of 100, the reference dose may be set at 0.025 mg/kg/day, or 0.25 mg total for a 10 kg child. At one liter per day, the recommended water criterion is 0.25 ppm (mg/liter) (USDA Forest Service 1984),

**2,4-DP**

Data for 2,4-D is generally assumed to represent 2,4-DP, and the same criterion is recommended.

For non-human life forms, protection of populations of organisms rather than the protection of each individual is the usual strategy, except when rare or endangered species are involved. Thus it would be unacceptable to kill all the individuals in a population of commonly abundant fish in a given portion of a stream, but may be acceptable if one or a few individuals were killed because they were unusually sensitive due to stress, or some other factor. The population of organisms would be expected to recover. Thus the strategy in establishing standards or water quality criteria for aquatics is the same as for humans, but the level of protection to be achieved (and the certainty) is different.

For regulatory purposes, the National Academy of Sciences (1973) Water Quality Criteria recommends 0.1(LCso) as a concentration not to be exceeded and is the relationship we use in establishing our recommended instantaneous maximum concentration criteria. Further, the National Academy of Sciences (1973) recommends O.01(LCso) as safe 24-hour average concentration. This is the strategy we used in developing our 24-hour average water concentration criteria.

We feel this is a conservative strategy because the nature of the exposure is greatly different in the field than it is in toxicity tests with aquatics. In the field, if a forest pesticide enters a stream the concentration typically reaches a peak and then decreases quickly as fresh, uncontaminated water flows in from upstream. Thus the organism is exposed to a variable concentration of pesticide. In toxicity tests, the concentration of pesticide is relatively uniform by comparison because the water is usually not exchanged, or if it is, fresh pesticide is added to maintain the concentration. Thus, in toxicity tests, organisms are exposed to fixed concentrations for prolonged periods compared to exposure in the field (Norris etal., 1983, 1991).

In the water quality criteria in Tables 3 and 4, the peak and 24-hour concentration criteria are specified for cold, fresh-water fish and for cold, fresh-water aquatic invertebrates based on the lowest reported LCso value for species which represent these types of organisms. The water quality criteria in Table 3 are for pesticides as they are used in forest management, For the peak concentration, the criteria are 0.1{LCso). For the 24-hour average concentration, the criteria are O.OI(LCso). Table 4 provides the criteria for the pesticides as they are used in nursery and Christmas tree management. The data in Table 4 are derived the same way as in Table 3 but an additional 5-fold safety factor is.added to allow for the uncertainty of the pattern of water contamination (and thus exposure) from nursery and Christmas tree operations.

Table 3. Forest management: Surface water quality advisory criteria which will provide protection for aquatic organisms.

| Pesticide | Aquatic Organism | | | |
| --- | --- | --- | --- | --- |
| | Invertebrates | | Fish | |
| | Instantaneous maximum | 24-hour average | Instantaneous maximum | 24-hour average |
| | --~ ..... mg/liter ........ | | ........ mg/liter ......... | |
| Asulam | Data not located | | >300 | >30 |
| Atrazine | 0.07 | 0.007 | 0.45 | 0.045 |
| Carbaryl | 0.00017 | 0.000017 | 0.07 | 0.007 |
| Dalapon | 0.1 | 0.01 | 34 | 3.4 |
| Dicamba | 0.39 | 0.039 | 3.5 | 0.35 |
| Diesel | 1.4 | 0.14 | 0.019 | 0.0019 |
| 2,4-D amine | 0.4 | 0.04 | 10 | 1.0 |
| 2,4-D ester | 0.01 | 0.001 | 0.06 | 0.006 |
| 2,4-DP ester[1] | 0.01 | 0.001 | 0.06 | 0.006 |
| Fosamine | 152 | 15.2 | 37 | 3.7 |
| Glyphosate (as Rodeo) | 93 | 9.3 | 60 | 6.0 |
| Glyphosate (as Roundup) | 0.3 | 0.03 | 0.13 | 0.013 |
| Hexazinone | 5.6 | 0.56 | 32 | 3.2 |
| Imazapyr | 10 | 1.0 | 11 | 1.1 |
| Picloram | 2.7 | 0.27 | 0.]5 | 0.015 |
| Simazine | 0.1 | 0.01 | 0.28 | 0.028 |
| Sulfometuron methyl | 1.2 | 0.12 | 1.2 | 0.12 |
| Triclopyr, amine | 5.6 | 0.56 | 11.7 | 1.17 |
| Triclopyr, ester | 0.032 | 0.0032 | 0.07 | 0.007 |

Values based on 2,4-D because of lack of adequate data base for 2,4-DP, and chemical similarity between 2,4-D and 2,4-DP

Values estimated, based on 167 fold higher toxicity of triclopyr ester to fish compared to triclopyr amine

Table 4. Forest tree seedling nursery and Christmas tree plantation management: Surface water quality advisory criteria which will provide protection for aquatic organisms.

| Pesticide | Aquatic Organism | | | |
|---|---|---|---|---|
| | Invertebrates | | Fish | |
| | Instantaneous maximum | 24-hour average | Instantaneous maximum | 24-hour average |
| | ........ mg/liter ........ | | ........ mg/liter ........ | |
| Acephate | 0.19 | 0.019 | 1.0 | 0.1 |
| Amitrole | 0.36 | 0.036 | 1.4 | 0.14 |
| Asulam | Data not located | | 60 | 6.0 |
| Atrazine | 0.014 | 0.001 | 0.og | 0.009 |
| Bifenthrin | 0.00004 | 0.000004 | 0.000002 | 0.0000002 |
| Chlorothalonil | Data not located | | 0.001 | 0.000] |
| Diesel | 0.28 | 0.028 | 0.004 | 0.0004 |
| Dienochlor | Data not located | | 0.001 | 0.0001 |
| Endosulfan | 0.00005 | 0.000005 | 0.000006 | 0.0000006 |
| Hexazinone | 1.12 | 0.11 | 6.4 | 0.64 |
| Mancozeb | 0.01 | 0.001 | 0,03 | 0.003 |
| Propargite | Data not located | | 0.002 | 0.0002 |
| Simazine | 0.02 | 0.002 | 0.05 | 0.005 |

The values in this task incorporate an additional five-fold safety factor to allow for uncertainty about patterns of exposure by water consumption in connection with the use of these pesticides in nursery and Christmas tree operations.

The following is a brief synopsis of the basis for the values in Tables 3 and 4. The values in Table 4 include the additional five-fold safety factor for nursery and Christmas tree uses of these pesticides.

Acephate: LCso greater than 50.mg/liter for yellow perch, ?st values are greater than ]00 mg/liter for trout of various species. Rainbow trout had LCsa of 1100 mg/liter, other tests with this species report LCsovalues of 730 mg/liter. This 96-hour LC50 for stonefly was 9.5 mg/litter (Johnson and Finley ]980 as referenced in USDA Forest Service ]989). For this report we use the 50 mg/liter figure as a conservative basis for the criterion for fish, and the value for invertebrates is for the stonefly nymph.

Amitrole: The most sensitive g6-hour LC50.value found for invertebrates is 18 mg/liter for the copepod, Cyclops vernal ls. For fish, the most sensitive 96-hour LCs0 value found was 70 mg/liter for yearling coho salmon. Other values are 325 mg/liter for the same species, age not specified (USDA Forest Service 1984).

Asulam: No data were found for invertebrates· The LCso was more than 5000 mg/liter for rainbow trout, and more than 3000 mg/liter for bluegill, which we used as the basis for the criterion.

Atrazine: The midge (Chironomus tentans) was the most sensitive invertebrate tested with atrazine (48-hour LC50 0.72 mg/liter) and is the basis for our criterion. In other tests with daphnia, scud, and Gammarus fasciatus (an amphipod) the 48-hour LC50 values were 5 to g mg/liter. Fish are slightly less sensitive, with the most sensitive 96-hour LC50 value being 4.5 mg/liter in rainbow trout. Brook trout and bluegill had 96-hour LC50's of 6 and 8 mg/liter. We used 0.72 mg/liter and 4.5 mg/liter as the basis for developing the criterion for invertebrates and fish (USDA Forest Service, ]984). The Canadian water quality guidelines cite a criterion for atrazine of 0.004 mg/liter, but it is based on effects on primary producers which are beyond the scope of this report.

Carbaryl: Shrimp (glass, mysid) are quite sensitive, with glass shrimp showing an LC50 value of 0.0056 mg/liter. Stonefly and daphnia are in the same range, while scud are less sensitive. The lowest g6-hour LC50 is 0.0017 mg/liter for stonefly, pteronarcella badia. Fish are less sensitive with the most sensitive g6-hour LC50 being 0.69 mg/liteh in lake trout, 1.95 mg/liter in rainbow trout and 4.3 mg/liter in coho salmon (USDA Forest Service 1989).

Chlorothalonil: No data were located for invertebrates. Rainbow trout had a 96-hour LC50 value of 0.05 mg/liter.

Dalapon: The most sensitive LC (24-hour) found for invertebrates was 1 mg/liter for stonefly (sodium salt of dalapon). In other tests, the 96-hour LC50 for stonefly was more than 100 mg/liter and for the dragonfly nymph more than 1600 mg/liter, all for the sodium salt. The lower value was used in this report as a basis for developing the criterion. The most sensitive LC50 for fish was 340 mg/liter for trout. This is the value used in this report. Values for other species include 115 and 500 mg/liter for bluegill, somewhat dependent of formulation. The sodium salt of dalapon as it is used in common commercial formulation caused LCso values of: 500 mg/liter for bluegill and 340 mg/liter for trout (USDA Forest Service 1984).

Dicamba: The amphipod, Gammarus lacustris is the most sensitive invertebrate to dicamba, with a 96-hour LCso of 3.9 mg/liter. Other invertebrates such as daphnia and scud are less sensitive at 11 and more than 100 mg/liter. Rainbow trout showed a 48-hour LCso of 35 mg/liter and bluegill showed 130 mg/liter. Coho salmon on the other hand showed no effect at 100 mg/liter (USDA Forest Service 1984).

Diesel: EPA reported a 96-hour LCso value for "fresh water fish" of 0.19 mg/liter for diesel and 1.2 mg/liter for No. 2 fuel oil, as cited in Weeks et al. (lg88b). This is believed to be the concentration dissolved in the water, rather than a surface residue. The LC50 for American shad was 125 mg/liter but this test included surface residues. This distinction is important, indicating that water quality tests must distinguish between surface (floating) oil film residues and residues in the water.

We suggest water samples analyzed for diesel oil or fuel oil be centrifuged and the surface layer discarded before analysis. The data for invertebrates is for blue crab, with an LC50 of 14.1 for No. 2 fuel oil. Weeks, et al., (1988b) report no other values.

2,4-D amine: There are many different values for the toxicity to invertebrates of the many amine forms of 2,4-D. The most sensitive value found was a 48-hour LCso of 4 mg/liter for daphnia for the dimethyl amine salt. The scud and crayfish are less sensitive to this form, with 48-hour LCso values of more than 100 mg/liter. Chinook salmon and rainbow trout showed 96-hour LC50 values of 100 mg/liter for dimethyl amine 2,4-D (bluegill were 168 mg/liter) (USDA Forest Service 1984).

2,4-D ester: The propylene glycol butyl ether ester was the most toxic form of 2,4-D ester to invertebrates. Findings are highly variable however, even for a single species. The most sensitive LCso (48-hour) found was 0.1 mg/liter, in Daphnia, which is the basis for our criterion. Numerous other values for several esters and various organisms are in USDA Forest Service (1984) Crayfish had a 48-hour LC50 value of more than.lO0 mg/liter. Stonefly were 2.6 mg/liter (96-hour LC50, cutthroat, rainbow and lake trout all showed g6-hour LCso values of I mg/liter for the propylene glycol butyl ether ester. Bluegill were slightly more sensitive at 0.6 mg/liter and in another test, cutthroat trout had a g6-hour LC50 of 0.8 mg/liter. Tests with other formulations show consistently higher LC50~ values (USDA Forest Service

Dienochlor: Data for invertebrates were not located. The LC50 is 0.05 mg/liter for rainbow trout and 0.6 mg/liter for bluegill.

Endosulfan: Endosulfan is reviewed extensively in NRCC (1975). They report a 72-120 hour LCso of 0.0003 gm/liter for rainbow trout. Other species of fish are such as they guppy and western white suchu are less sensitive (LC50 0.003 to 0.005 mg/liter). The harlequin fish is much more sensitive (24-hour LC50 0.00002 mg/liter) but we use the trout as a more representative species for forest ecosystems (NRCC 1975). Thus, for fish our criteria are derived from the LCso of 0.0003 mg/liter. For invertebrates,the stonefly with a 96-hour LC50 of 0.0023 mg/liter is selected as the basis for the criteria (NRCC 1975). The fish as the most sensitive type of aquatic fauna has a 24-hour average criterion for nurseries and Christmas trees of 0.0000006 mg/liter. This is much lower than the Canadian standard of 0.00002 mg/liter which.considered but apparently did not use the 0.0003 mg/liter LCso. They appeared to have used an LCso of 0.002 mg/liter. Our criterion may be too conservative.

Fosamine: The 48-hour LCso for fosamine for invertebrates is ]524 mg/liter (daphnia), based on a single reported test. For fish, the 96-hour LOs0 is 367 mg/liter (for rainbow trout yolk-sack fry). The egg stage was much less sensitive (96-hour LCs0 1456 mg/liter) and coho salmon showed no response at 200 mg/liter over six days (USDA Forest Service 1984).

Glyphosate: We provide.separate criteria for glyphosate as Rodeo and as Roundup to allow more meaningful development of standards for this herbicide in its different formulations.

Roundup: Daphnia showed the most sensitive 48-hour LC50 for invertebrates at 3 mg/liter to the Roundup formulation. In other tests the 48-hour LCs0 for daphnia was 5.3 and 192 mg/liter for this same formulation. We used the lowest LC50 as the basis for the criterion we recommend. Other species had 48-hour LC50 values of 13 mg/liter (midge, Chirononua plumosus), 62 mg/liter (amphipod) and a 96-hour LCso of more than 1000 mg/liter for. crayfish. Among cold water fishes tested, rainbow trout is. most sensitive with.a 96-hour LC50 of 1.3 mg/liter for Roundup formulation (USDA Forest Service 1984, WeeKs et al. 1988).

Rodeo: The surfactant in the Roundup formulation is apparently a major contributor to this toxicity, since formulations without the surfactant (such as Rodeo) show Lc500 values which are much higher. The 96-hour LC50 for the surfactant alone is 2 mg/liter for rainbow trout and 3 mg/liter for bluegill. The 96-hour LC50 values for Rodeo are 680 mg/liter for trout, 750 mg/liter for Chinook salmon, 600 mg/liter for Coho salmon and 930 mg/liter for daphnia (Weeks et al. 1988).

Hexazinone: The 96-hour LC50 for.invertebrates is 56 mg/liter on grass shrimp and the 48-hour LC50 is 52 mg/liter for daphnia. The rainbow trout shows an LC50 value of 320 mg/liter (bluegill was 370 mg/liter) (USDA Forest Service 1984).

Imazapyr: The48-hour LC50 in Daphnia is greater than 100 mg/liter for technical imazapyr, 750 mg/liter for isopropylamine salt and 350 mg/liter for Arsenal formulation. Fish are similar in sensitivity, with rainbow trout showing a 96-hour LC50 of 110 mg/liter and bluegill 180 mg/liter for Arsenal (Weeks et al, 1988c).

Mancozeb: The EPA Fact Sheet on this pesticide reports what we believe is the LC o in daphnia as 0.58 mg/liter and 1.54 mg/liter in rainbow trout (EPA 19871.

Picloram: The range of LC50 values for fish is large for picloram, but. most are greater than 10 mg/liter. The most sensitive value is for cutthroat trout at 1.5 mR/liter {96-hour LCso). The scud, Gamarus lacustris, is the most sensitive invertebrate with a 96-hour LC50 of 27 mR/liter. Other 96-hour LCs0's are 48 mg/liter for stonefly nymph and 50 mg/liter for water flea (Weeks et al. 1988).

Propargite: Data not located on invertebrates. Rainbow trout and bluegill show LC50 values of 0.12 and 0.1 mg/liter.

Simazine: The invertebrate criterion in this report is derived from a g6-hour LC50 of 1.1 mR/liter for daphnia. Other species are less sensitive (amphipod 96-hour LC50, 13 mg/liter, crayfish 96-hour LC50, > 100 mR/liter; stonefly.g6-hour LC50, 1.9 mg/liter). Rainbow trout have a similar level of sensitivity, with 96-hour LC50 values in various test of 2.8 and 5.6 mR/liter. Other tests show much higher values. Other species are less sensitive (USDA Forest Service 1984).

Sulfometuron methyl: The daphnia, rainbow trout and bluegill all have 96-hour LCso values greater than 12.5 mR/liter, but a specific LC50 is not identified for these species. Thus, we have used the 12.5 value as a conservative estimator of the 96-hour LC50 in deriving the criteria for this herbicide (Weeks et al. 1988).

Triclopyr, amine: The daphnia showed a 21-day LCso value of 1140 mg/liter for triclopyr triethylamine salt in a 21-day test (with replacement of test solution three times per week). Some salt water species appear slightly to much more sensitive. For instance, shrimp (representative of crustaceans) had a 96-hour LC50 value of 895 mg/liter and oysters (representative of mollusks) had a 48-hour LCso value of 56 mg/liter. We use this later value as the guide for this report. For fish, the triclopyr 96-hour LC50 value is 117 mg/liter for rainbow trout and 148 mg/liter for bluegill exposed to the triethylamine salt. The formulated product Garlon 3A is less toxic with 96-hour LC50 values of 552 mg/liter for rainbow trout and 841 mg/liter for bluegill (USDA Forest Service 1984).

Triclopyr, ester: For fish the 96-hour LC50 is 0.74 mg/liter for rainbow trout and 0.87 mg/liter for bluegill for exposure to Garlon 4 (the butoxyethyl ester). Specific data for invertebrates are lacking. For invertebrates we assume the ester is 167 times more toxic than the amine, the relationship reported for fish, giving an estimated g6-hour LC50 of 0.3 mg/liter (USDA Forest Service 1984).

## SECTION 3 WATER QUALITY STANDARDS TO ASSURE PROTECTION OF HUMAN HEALTH, AQUATIC ORGANISMS AND OTHER ANIMALS

In forestry operations it is desirable to set water quality standards that trigger a management response at some concentration less than considered virtually safe by regulatory bodies. With that approach, the response to exceedance of standards need not be an immediate health protective action, but rather an examination of the practices leading to the finding to determine if procedures should be changed.

The concentrations of pesticides in surface water identified in Tables I-4 are those which if not exceeded we believe will assure protection of human health, aquatic organisms, and other animals, depending on the pattern of use. Based on current knowledge, we are confident in these values because the assumptions used in their derivation are conservative and margins of safety are incorporated to provide for uncertainty and for extrapolation of laboratory data to field settings.

In this section we identify (Tables 5 and 6} the concentration {criteria} of each pesticide which will protect aquatics (24-hour average exposure), and humans and other animals (10-day exposure for forest management uses, lifetime exposure for nursery and Christmas tree uses). These criteria are for use of pesticides according to the label and best management practice in (a) forest management (Table 5), and (b) forest tree seedling nursery and Christmas tree plantation management (Table 6). We believe these criteria can be the basis for establishing water quality standards.

In many cases, we feel the criteria we recommend are higher than should occur under best management practices (BMP). We advocate minimizing exposure. Thus, if BMP generally are successful in preventing water contamination, even at levels below the criteria we recommend, we feel the criteria should be dictated by that achievable by BHP. In no case, however, should BMP be allowed if they result in water contamination levels while exceed our recommended criteria. Thus, the strategy is: (a) do not exceed the criteria we recommend, and (b} if BHP generally leads to even lower concentrations, those should be the guide. Our criteria should *not* be seen as "permissible pollution levels," but rather the levels not to be exceeded.

Table 5. Forest management: Recommended regulatory and management criteria for concentrations of selected pesticides in surface water.

| Pesticides | Concentration which protects both aquatics and humans[1] {except as noted} | Most sensitive group of organisms | Recommended water quality criteria |
|---|---|---|---|
| | ---mg/liter--- | | ---mg/liter--- |
| Asulam[z] | 1.0 | human | ].0 |
| Atrazine | 0.007 | aquatic | 0.007 |
| Carbaryl | 0.000017 | aquatic | 0.00002 |
| Oalapon | 0.01 | aquatic | 0.01 |
| Dicamba | 0.039 | aquatic | 0.04 |
| Diesel | 0.0019 | aquatic | 0.002 |
| 2,4-0 amine | 0.04 | aquatic | 0.04 |
| 2,4-D ester | 0.001 | aquatic | 0.00! |
| 2,4-DP ester | 0.001 | aquatic | 0.001 |
| Fosamine | 2.0 | human | 2.0 |
| Glyphosate (as Rodeo) | 6.0 | aquatic | 6.0 |
| Glyphosate (as Roundup) | 0.0]3 | aquatic | 0.01 |
| Hexaztnone | 0.56 | aquatic | 0.6 |
| Imazapyr | ].0 | aquatic | 1.0 |
| Picloram | 0.015 | aquatic | 0.015 |
| Simazine | 0.01 | aquatic | 0.01 |
| Sulfometuron methyl | 0.] | human | 0.1 |
| Triclopyr, amine | 0.25 | human | 0.25 |
| Triclopyr, ester | 0.003 | aquatic | 0.003 |

Protection for aquatics is based on 24-hour average exposure level and humans on a lO-day exposure.

Data lacking on aquatic invertebrate organisms.

Table 6. Forest tree seedling nursery and Christmas tree plantation management: Recommended regulatory and management criteria for concentrations of selected pesticides in surface water.

| Pesticides | Concentration which protects both aquatics and humans[1] (except as noted) | Most sensitive group of organisms | Recommended water quality criteria |
|---|---|---|---|
| | ---mg/liter--- | | ---mg/liter--- |
| Acephate | 0.001 | human | 0.001 |
| Amitrole | 0.0004 | human | 0,0004 |
| Asulam[2] | 0.2 | human | 0.2 |
| Atrazine | 0.00] | aquatic | 0.001 |
| Bifenthrin | 0.0000002 | aquatic | O. 0000002 |
| Chlorothalonil[2] | 0.0001 | aquatic | 0.0001 |
| Diesel | 0.0004 | aquatic | 0.0004 |
| Dienochlor | 0.0001 | aquatic | 0.0001 |
| Endosulfan | 0.0000006 | aquatic | O. 0000006 |
| Hexazinone | 0.]1 | aquatic | 0.11 |
| Mancozeb’ | 0.001 | aquatic | 0.001 |
| Propargite[2] | 0.0002 | aquatic | 0. 0002 |
| Simazine | 0.002 | aquatic | 0. 002 |

Protection for aquatics is based on 24-hour average exposure level and humans on a lifetime exposure.

Data lacking on aquatic invertebrate organisms.

## CONCLUSIONS

Based on our analysis we conclude it is possible to idnetify water quality criteria which when rationally applied for management and regulatory purposes will protect human health and the welfare of aquatic and other organisms. We have identified these criteria as surface water concentrations which if exceeded should trigger evaluation of the practice, and perhaps other actions.

We have developed separate criteria for two broad classes of pesticide use, a) forest management and b) the management of forest tree seedling nurseries and Christmas tree plantations. These criteria for nurseries and Christmas tree operations are more conservative because we lack a significant data base for water contamination from this pattern of pesticide use. Our criteria in this case are provisional, and they should be reevaluated when monitoring data is available.

Any analysis of risk (which leads to the water quality criteria) is based on the knowledge available at the time. It is likely more information on toxicity and exposure will be available in the future. It is important that water quality criteria which guide management and regulatory programs be reviewed periodically to ensure the criteria remains consistent with the goals and the best available data.

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