Pesticide Use in Mendocino County's Timber and Winegrape Industry: Contaminants & Our County†

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Background on Pesticide Use in Agricultural Ecosystems

Agricultural lands play critical roles in addition to producing food and fiber. Agricultural ecosystems serve an environmental function preserving biological diversity, soil and water systems, and landscape. However, the adoption of intensive agricultural systems has led to limitations in production and environmental function. Limitations include increasing competition from weeds, fungus, nematodes, and insects. Regrettably, the primary strategy used for eliminating these so-called "pests" has been the broad use of synthetic, chemically derived pesticides. While there has been a gradual move away from chemically derived pest control to integrated pest management systems that utilize natural pest controls, the dominant form of pest control in agriculture includes the application of synthetically derived chemical-based pesticides.

Approximately 2,500,000 tons of synthetic pesticides are applied annually to crops worldwide. About 600,000 tons (or about 25%) are used in the United States. The heavy reliance on synthetic chemical pesticides is having serious impacts on public health and the environment.[1] The increasing use of synthetic pesticides is decimating natural pest controls, creating increased pesticide resistance, and damaging human and ecosystem health.[2]

A synthetic pesticide is defined as a chemical or compound used to control, repel, or kill pests that compete with humans for food, destroy property, or are considered a nuisance. Pests can include competing organisms or competing vegetation. Pesticides are also defined as poisons that are dangerous to living things – including humans, fish, birds, beneficial insects, and plants.

Whereas pesticides are used for precise purposes, to eliminate weeds, kill fungus, and eradicate insects – all of which can damage crops—chemicals can move off site and create non-target impacts. A small share of pesticides applied on a given field or in a given area actually reaches the intended target.[3] It is estimated that less than 0.1 per cent of the pesticides applied to crops reach the target pests.[4] Thus, more than 99 per cent of applied pesticides have the potential to impact non-target organisms and become widely dispersed in the environment as potential contaminants. Pesticide losses can result in the contamination of groundwater, surface water, the atmosphere and surrounding soils where they can have damaging effects on wildlife, plant life, soil and water organisms, and humans.[5] Because society bears the impacts and costs of these damages, we must consider indirect damages.

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Human pesticide poisonings and health-related impacts are the most controversial outcome from pesticide use. Health-related impacts include potential cancers, reproductive toxicity, neurotoxicity, rashes, immune system damages, and acute toxicity.[6] In 1989, the World Health Organization and United Nations Environmental Program released the publication "*Public Health Impact of Pesticides Used in Agriculture*" which reported that there are about 1 million human pesticide poisonings and 20,000 deaths each year directly related to the application of pesticides. Nationwide the use of synthetic pesticides is estimated to cause health impacts totaling as much as $786 million dollars a year.[7]

Environmentally, many types of non-pest organisms are also adversely affected by pesticide applications. Pesticides can interact with wildlife producing acute poisonings, sublethal effects, and alterations to habitat. For example, in the United States, estimates suggest that 20 % of honeybee colonies are inadvertently eradicated by pesticide application. And, increasing attention is being given to the effects of pesticides on fish species. In particular, endangered and threatened salmon species are being placed at an increased risk by direct and indirect risks from pesticides. Indirect effects affect habitat and food sources whereas direct toxicity of the pesticides can impact the fish species at varying life stages. Overall, the estimated environmental and health care costs of pesticides used at recommended levels in the United States runs about $12 billion every year.[8]

Most residents in Mendocino County are most likely unaware of the profuse utilization of industrial poisons in our small corner of the world and its potential cost to the health of residents and our ecosystems. By assessing pesticide use within Mendocino County's two main agricultural economies, timber and wine grape production, two goals may be achieved. The first includes providing educational information to increase public awareness of the most widely used (by volume) synthetic pesticides in Mendocino County's main. The secondary aim of the project includes highlighting three specific pesticides of concern or significance[9] within those industries for duel purposes; (1) to provide additional education for chemicals of toxicological concern, and (2) to identify specific pesticides for future campaigns which could be focused on reduction of use.

Mendocino County's Main Economic Agriculturally Based Industries

Mendocino County is home to diverse number of agricultural crops. Most of the crops are stationary or orchard-related crops such as apples, pears, grapes, and timber. The county's primary crops in terms of economic value are timber and wine grapes. While timber production is decreasing, wine grape cultivation is on the rise. In the past 10 years the economic value of wine grapes has increased from $40 million in 1992 to $70 million in 2003. According the Mendocino County Department of Agriculture, 2,500 acres (42 farms) are cultivated organically. Organic wine grape production accounts for approximately 15% of the total land in wine grapes. The remaining wine grape bearing acreage (13,500 acres) uses approximately 660,000 pounds of pesticides.[10]

Timber production, while on the decline, ranks second in the County in agricultural economic value.[1] In 2003, Mendocino County harvested and produced 112,500,000 million board feet of timber with a total value of $67 million. Mendocino County continues to rank

[1] According to the 2003 Mendocino County Crop Report. The 2004 report is not yet publicly available although preliminary figures show timber and wine as the top two crops in economic value. Timber is valued at $67 million and wine is valued at $60 million.

fourth in the state in timber producing counties behind Humboldt, Shasta, and Siskiyou. In 2003, approximately 10,000 pounds of pesticides were used in the timber management industry.

Pesticide Usage in Mendocino County's Timber and Wine Grape Production

Mendocino County uses nearly 1.5 million pounds, or 750 tons, of synthetic pesticides per year. Pesticides are readily used on the primary crops grown in Mendocino County; wine grapes and timber. Conventional vineyard cultivation uses considerably more pesticides (by pound of active ingredient) than is used in forest and timber management. According to the 2003 California Department of Pesticide Regulation Use Data, approximately 660,000 pounds of pesticides are used in Mendocino County's winegrape industry whereas approximately 10,000 pounds of pesticides are used in the logging industry. Eight (8) pesticides used in both industries have identified for further illumination based solely on volume of use (depicted in pounds) within the county.

Table 1.depicts the pesticides with roughly the greatest and most consistent use by pound of active ingredient between the four growing years, 2000- 2003, for Mendocino County's timber and winegrape industries. Table 1. shows that the primary pesticides identified vary by use from year to year.

Table 1. Pesticides by Pounds of Use; 2000-2003

Industry	**Pesticide**	**Class**	**2000**	**2001**	**2002**	**2003**
Timber	Imazapyr	Herbicide	6690	7607	5368	2974
Timber	2,4-D	Herbicide	.57	1.4	14	1286
Timber	Triclopyr	Herbicide	1378	43	153	1910
Winegrape	Mancozeb	Fungicide	3832	2842	1891	2008
Winegrape	Oryzalin	Herbicide	2727	640	281	2127
Winegrape	Oxyfluorfen	Herbicide	2936	2946	4069	3406
Winegrape	Simazine	Herbicide	4729	3098	2712	1996
Winegrape	Glyphosate	Herbicide	13,083	13,844	15,500	15,468

Spotlight on Eight Pesticides used in the Timber and Wine Grape Industry:

Eight pesticides have been chosen for further elucidation based on their sheer volume of use. Volume is measured in pounds of pesticide applied within the timber and wine grape industry. To fully understand each chemical's unique toxicity, human health studies and the physical properties have been considered.

The physical properties point out how the chemical may act once it moves off target and is released into the environment. For example, the physical properties of a pesticide begin to answer questions such as, "Will this pesticide run off into streams when it rains?" or "How long will it take for this pesticide to break down in the environment?" Appendix A. defines a number of physicochemical parameters that provide guidance on the effect pesticides may have as they move off site of application and into the surrounding environment.

1. Imazapyr

Imazapyr is the most widely used (per pound of active ingredient) broad-spectrum herbicide in the northern California logging industry. The active ingredient, imazapyr, is marketed in compounds by the trade names, Chopper, Arsenal, and Assault. *Its average annual use in Mendocino's timber industry from years 2000-2003 is 5660 pounds.*

Imazapyr's primary route of potential harm to humans would occur during the application process. If contact occurs, imazapyr is irritating to the eyes and can cause rashes, redness and swelling at the site of exposure. Imazapyr is not a carcinogen and has no known reproductive effects.

Non-target environmental effects to the environment occur primarily due to the lack of distinguishing between the plants it kills. Thus, rare and endangered plants are particularly at risk from exposure to the herbicide. The Environmental Protection Agency, overseeing the potential risks to endangered and threatened plant species has stated that "jeopardy" will occur to terrestrial and aquatic plant species from the use of Arsenal.[11]

In soils, imazapyr is persistent. The EPA reports that the half-life of imazapyr is 17 months.[12] If applied to soil, imazapyr is expected to have very high mobility and thus is likely to contaminate water. Studies have detected imazapyr in surface as well as groundwater. If released into water or if the chemical moves through soils and finds its way to water, imazapyr is not expected to adsorb to suspended solids and sediment based upon the chemical's adsorption coefficient. However, studies on the effects of imazapyr to macroinvertebrate communities did not yield effects[13] and the chemical is not expected to have impacts to salmon species.

2. 2,4-D

2,4-D is general use pesticide. Its commercial names include Barrage, Salvo, and Weedone. The chemical's average annual use in Mendocino County is 325 pounds with the most significant use in 2003.

2,4-D use is of particular concern due to its toxicity to both humans and wildlife. In humans, 2,4-D is effects on the nervous system (which is highly unusual for herbicides), reproduction, and its linkage with the onset of non-Hodgkin's lymphoma.

One of the most common neurotoxic symptoms associated with 2,4-D exposure is myotonia. Myotonia occurs when muscles are unable to relax after a voluntary contraction.13 Myotonia is routinely induced in laboratory experiments by administering 2,4-D.[14,15]
Male farmworkers exposed to 2,4-D suffer from significant reduction in sperm production. And, of the sperm produced, nearly twice as many sperm were considered abnormal.[16]

The carcinogenic potential of 2,4-D remains unclear even though the chemical's association with non-Hodgkin's lymphoma has been studied and documented since the 1970s. A compelling study was conducted by the National Cancer Institute and found an association between use of 2,4-D and non- Hodgkin's lymphoma. Results showed a "a 50% excess of NHL associated with mixing or applying 2,4-D."[17]

Ecologically, 2,4-D has been shown to have effects on earthworms and fish. 2,4-D is highly toxic to earthworms.[18] Effects to fish occur at acute and sublethal levels. The chemical is considered to be highly toxic to fish, particularly juvenile pink salmon, juvenile chum, and bluegills. [19]

3. Triclopyr

Triclopyr is perhaps better known by its trade name, Garlon. Triclopyr is a selective systemic herbicide used for control of woody and broadleaf plants primarily in forests. This pesticide has received a lot of attention through the years due to its distant affiliation with 2,4,5-T, which has been banned in the United States. The form of triclopyr used in Mendocino County is the butoxyethyl ester (TBEE), or Garlon® 4. *Its average annual use in Mendocino's timber industry from years 2000-2003 is 871 pounds.*

The primary concerns surrounding the use of triclopyr in silvicultural practices is its effect to wildlife, particularly amphibians, fish, and aquatic organisms. In order for triclopyr to pose a threat to aquatic species, the pesticide would need to be apt to move through soils into surface and groundwater. Studies regarding triclopyr's mobility in soils have been conflicting.

While Dow chemical's studies point to its low mobility,[20] EPA calls it very mobile in soil, with the potential to leach into groundwater.[21] The United States Geological Survey found Triclopyr in 90% of sites sampled.[22] And, the pesticide's primary breakdown product, 3,5,6-trichloro-2-pyridinol (TCP), has been found to be mobile in sand, sandy loam, silt loam, and clay soils. [23] Tricolpyr's persistence in the environment is also of concern. The measured half-life in soils has varied from 10 to 100 days, with greater persistence in forestry sites.[24] This means that the chemical stays active in the soil for some time after application.

Triclopyr's mobility coupled with its persistence produce potential impacts to wildlife. The ester formulation used in Mendocino County is highly toxic to fish and has also been shown to disrupt alarm responses in studies involving frogs. In one study, three species of frogs subjected to low concentrations of triclopyr suffered from an inhibition of avoidance behavior when faced with prey.[25] Garlon®4 has also been found to be 17 times more toxic to frog embryos than Garlon 3A.[26]

Garlon®4 has been found to be highly toxic to cold-water fish such as trout and salmon. At levels as low as .5ppm, triclopyr ester can affect the yolk-sac fry of the Coho salmon.[27] Triclopyr's butoxyethyl ester also affects fish behavior. In laboratory tests with rainbow trout, concentrations of 0.6 ppm resulted in rapid respiration, flared gills, and erratic, disoriented swimming.[28]

4. Mancozeb

Mancozeb is also better known by its trade names including Dithane, Manzeb, and Nemispot, is a broad spectrum fungicide. *Its average annual use in Mendocino's wine grape industry from years 2000 through 2003 is 2643 pounds.*

The use of Mancozeb presents a risk to human health as well as wildlife. In humans exposure to mancozeb can produce an inhibition of cholinesterase resulting in effects to the nervous system. Symptoms of exposure include fatigue, headache, blurred vision, nausea, and tremors. At high doses exposed persons can have convulsions, slurred speech, confusion, and slowed heartbeat. In lower doses, mancozeb can also cause a skin rash if the chemical has contact with the skin. In one study, a vineyard worker developed a rash on the forearm as well as inflammation of the eyelids after handling seedlings, which had been treated with mancozeb.
In addition to mancozeb's cholinesterase effects, the pesticide's primary metabolite is ethylenethiourea (ETU). ETU has been shown to cause thyroid and carcinogenic effects in test animals. Because of ETU, mancozeb is listed as a chemical known by the State of California to cause cancer in humans. Its carcinogenic status coupled with studies showing the pesticide can cross the placental barrier and can produce DNA damage and initiate tumors in fetal cells should provide convincing support for the pesticide's reduction is use.[29]

In addition to mancozeb's potential risks to humans, the pesticide is highly toxic to fish and other aquatic organisms. Once applied, the pesticide rapidly degrades to ETU, which has been shown to be mobile in soils.[30]

5. Oryzalin

Oryzalin, also known as Surflan, is a pre-emergent herbicide used to control grasses and weeds in vineyards. *Its average annual use in Mendocino's wine grape industry from years 2000 through 2003 is 1444 pounds.*

Exposure to oryzalin, either to humans or wildlife, poses significant concerns. The potential risks to human health are primarily attributed to the chemical's status as a possible carcinogen and its potential in being an endocrine disruptor.

The endocrine system is a complex network of glands and hormones that regulates many of the body's functions, including growth, development, and maturation. The endocrine glands -- including the pituitary, thyroid, adrenal, thymus, pancreas, ovaries, and testes -- release carefully-measured amounts of hormones into the bloodstream that act as natural chemical messengers, traveling to different parts of the body in order to control and adjust many life functions. An endocrine disruptor is a synthetic chemical that when absorbed into the body either mimics or blocks hormones and disrupts the body's normal functions. A recent study verified earlier studies identifying Surflan and the active ingredient oryzalin as endocrine disruptors acting similarly to endogenous estrogen. The study pointed out that Surflan and oryzalin activated an estrogen-inducible reporter gene, and oryzalin competitively displaced 17beta-estradiol from the estrogen receptor. These results are consistent with the characteristics of previously identified xenoestrogens and indicate that Surflan and oryzalin have the potential to adversely affect numerous estrogen-regulated biological processes.[31]

Oryzalin is also listed as a Class C, possible human carcinogen.[32] In one experiment Oryzalin has produced thyroid tumors and benign skin and mammary tumors.[33] When the EPA completed the reregistration decision for oryzalin in 1994, it stated that pesticide applicators applying oryzalin would exceed the acceptable level of cancer risk (1 in a million) whether or not the application took place with a low-pressure hand wand, backpack sprayer, or ground boom sprayer. The EPA concluded that protective clothing "should adequately mitigate risk."[34]

Oryzalin poses a risk to aquatic wildlife. The pesticide is considered moderately mobile.The U.S. Geological Survey found oryzalin in rivers, streams, or wells in almost half (16 of 36) of the river basins that the agency has tested nationwide.[35] Oryzalin is classified as "moderately toxic" to fish because between 2 and 3 ppm are sufficient to kill fish. Juvenile fish are even more susceptible; less than 1 ppm caused adverse effects.[36]

6. Oxyfluorfen

Oxyfuorfen, also known as Goal, is a broad-spectrum pre and post-emergent herbicide used to control weeds. *Its average use in Mendocino's wine grape industry from years 2000 through 2003 is 3336 pounds.*

Oxyfluorfen is of specific toxicological concern based on its environmental toxicity. It is classified as a very highly toxic and a very persistent herbicide and is a concern for aquatic organisms and birds. The primary route of exposure for birds, and aquatic organisms is through spray drift or soil erosion runoff into waterways. 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.[37]

<u>Aquatic Ecosystems</u>

Oxyfluorfen has the potential to affect aquatic ecological systems at all trophic levels, as it is toxic to plants, invertebrates, and fish. Based on toxicity data to invertebrates, oxyfluorfen may pose long-term effects to benthic organisms. The benthic environment (aquatic soil environment) provides habitat to many invertebrates that provide important food sources to fish and other aquatic organisms. Because of oxyfluorfen's high affinity to soil, soil eroding from application areas is likely to carry bound oxyfluorfen to aquatic areas.

<u>Birds</u>

Sub-chronic and chronic risks to terrestrial birds and mammals present a serious concern. These toxic effects may be manifested as reproductive and developmental consequences. In a bobwhite quail reproduction study, reduced chick weights were observed, which would reduce fitness if experienced in the wild. In developmental toxicity studies, increases in spontaneous abortions, fetal resorptions, and fetal bone deformities as well as decreases in litter size were observed. Any of these effects would have an effect on the fitness of individuals, and may have an effect on the overall fitness of wild populations.

<u>Human Health</u>

Oxyfluofen is not a known neurotoxin, reproductive toxin, or teratogen, and it is considered relatively non-toxic. However, oxyfluorfen is classified as a category C, possible human carcinogen based upon combined liver adenomas/carcinomas in a mouse carcinogenicity study.

7. Simazine:

Simazine was introduced in 1956 by the Swiss company J. R. Geigy and is part of the triazine family of chemical compounds. Syngenta currently produces Simazine. The compound has been heavily used as an herbicide because it is effective at inhibiting the photosynthetic processes in annual grasses and broadleaf weeds. *The average annual use of simazine in Mendocino County is 3119 pounds.*

Simazine is a Class C (possible) carcinogen based on inconsistencies in the data derived from cancer bioassays. The chemical's primary concern is associated with its ability contaminate ground and surface waters. The presence of simazine in water systems has been widely reported.[38] Further studies found simazine was present in a number of groundwater wells in North Carolina, Illinois, and Wisconsin, respectively.[39,40]

Of particular concern for Mendocino County's simazine's use are studies reporting that the chemical is more likely to contaminate surface water when used in no-till fields such as mature orchards where it is applied in significant concentrations and no tillage takes place.[41,42]

8. Glyphosate:

The active ingredient in the world's best selling broad-spectrum herbicide Roundup®, is glyphosate. Roundup® has been on the worldwide market for decades and has been under scrutiny for just as long. Roundup®, produced by Monsanto, is a mixture of glyphosate and other chemicals (commonly referred to as "inerts") designed to increase the herbicide's penetration into the target and its toxic effect. Since inerts are not listed as "active ingredients" the U.S. Environmental Protection Agency (EPA) does not assess their health or environmental impacts, despite the fact that more than 300 chemicals on EPA's list of pesticide inert ingredients are or were once registered as pesticide active ingredients, and that inert ingredients often account for more than 59% of the pesticide product by volume. Early toxicological concerns centered on the chemical's primary inert ingredient, polyethyloxylated tallow amine (POEA). The POEA accounts for upwards of 59% of product by volume. This inert ingredient has a lethal dose less than one third that of glyphosate, making POEA three times as toxic as the active ingredient itself.[43]

A recent study of Roundup presents new evidence that the compound may be an endocrine disruptor. The study reports glyphosate toxicity to human placental cells within hours of exposure, at levels ten times lower than those found in agricultural use. The researchers also tested glyphosate and Roundup at lower concentrations for effects on sexual hormones, reporting effects at very low levels. This suggests that dilution with other ingredients in Roundup may, in fact, facilitate glyphosate's hormonal impacts.[44] The evidence presented in the recent study is supported by earlier laboratory studies connecting glyphosate with reproductive harm, including damaged DNA in mice and abnormal chromosomes in human blood.[45]

The Environmental Protection Agency has classified glyphosate as category E (evidence of non-carcinogenicity for humans). The EPA’s Toxicology Branch Ad Hoc Committee first considered Glyphosate’s carcinogenic potential in 1985. Glyphosate was then considered a Group C carcinogen, based in an increased incidence of renal tumors. These findings were referred to the Scientific Advisory Panel (SAP), which in 1986 classified glyphosate as a Group D carcinogen (inadequate animal evidence of carcinogenic potential). The SAP concluded that the carcinogenic potential of glyphosate could not be determined from existing data and proposed that the rat studies be repeated. Upon receipt of the second rat chronic/ carcinogenicity study, all findings were referred to the Health Effects Division Carcinogenicity Peer Review Committee. In 1991, the Peer Review Committee classified glyphosate as Group E based on a lack of convincing evidence.[46]

Studies have also documented glyphosate's toxicity to wildlife and especially to amphibians. Recently, studies conducted in small ponds with a variety of aquatic populations have presented evidence that levels of glyphosate currently applied can be highly lethal to many species of amphibians.[47]

Glyphosate is the world's most commonly used agricultural pesticide, and the second most-applied residential pesticide in the U.S. Recent evidence notwithstanding, glyphosate is considered less hazardous than other herbicides, an attitude that has increased the pesticide's use and desensitized policymakers to its impacts. The herbicide is used in both forestry and wine grape production to reduce weeds, grasses, shrubs and trees that compete with commercial timber trees and vines. In Mendocino County, glyphosate is used primarily in the wine grape industry.

Ranking Pesticides by Toxicity

In the United States, the Environmental Protection Agency (EPA) is responsible for registering pesticides and determining where they may and may not be used. However, the EPA does not regulate pesticides by volume of use nor does the agency compare or rank the environmental risks from the use of various pesticides having nearly identical uses.

In its place, the EPA establishes legal limits for pesticide use by rate of use—pounds of active ingredient divided by the acres treated. This system fails to encourage a decrease or reduction in total volume. In addition, the EPA does not rank pesticides by their inherent environmental risks. By comparing pesticides through the assessment of environmental impacts, we can better facilitate precautionary policy measures by identifying and attempting to decrease use of those pesticides that carry the greatest negative environmental and human health impacts.

Throughout the years, a number of ranking systems have been created. For example, the first ranking system, developed in 1975, was called “Metcalf’s Pest-Management Rating of Insecticides.” Other ranking systems include the “Stemilt Growers Rating Scheme,” the “Ipest Decision Tool,” the “Synops Model,” and the “Environmental Impact Quotient.”

In order to begin to rank the eight pesticides highlighted in this report, the Environmental Impact Quotient (EIQ) has been utilized based on the tool’s comprehensiveness. The EIQ was designed by Integrated Pest Management specialists to aid fruit and vegetable growers of New York State in choosing low impact pest-control options.[48] The EIQ considers eight environmental parameters: 1) the effect of pesticides on pesticide applicators, 2) harvesters, 3) consumers, 4) groundwater, 5) fish, 6) birds, 7) bees, and 8) beneficial arthropods. A composite EIQ score is calculated for each pesticide’s active ingredient using an algebraic equation to combine the numerical ratings assigned to each of these effects. The underlying premise of the EIQ method is that impacts result from the interaction of toxicity and exposure.[49]

The formula for determining the EIQ value of individual pesticides is:

EIQ={C[(DT*5)+(DT*P)]+[(C*((S+P)/2)*SY)+(L)]+[(F*R)+(D*((S+P)/2)*3)+(Z*P*3)+(B*P*5)]}/3 EIQ x % active ingredient x rate (lbs/acre treated)

The Environmental Impact Quotient Ranking System has been used to establish quotients for the eight identified pesticides used in Mendocino timber and wine grape industries See Table 2.

Table 2: Environmental Impact Quotients for Eight Identified Pesticides

Pesticide	Commodity	EIQ
Imazapyr	Timber	18
2,4-D	Timber	19
Triclopyr	Timber	9
Mancozeb	Grapes	15
Oryzalin	Grapes	19
Oxyfluorfen	Grapes	34
Simazine	Grapes	15
Glyphosate	Grapes	15

Once a general EIQ score is generated, a situation-specific “Field Use Rating” can be generated based on actual pounds of pesticides used in a given area. The equation for obtaining a field use rating is:

EIQ Field Use Rating = EIQ x % active ingredient x rate of application

The EIQ “Field Use Rating” accounts for the % of pesticide active ingredient multiplied by the rate of application.

Table 3. depicts the EIQ Field Use Rating for the eight identified pesticides used in Mendocino timber and wine industries. The percent % product and the rate of application was obtained from

the most recently available pesticide use reports compiled by the California Department of Pesticide Regulation.[50]

Table 3. Mendocino County Environmental Impact Quotient Field Use Rating for Eight Identified Pesticides

Pesticide	Chemical Code	% Active Ingredient[51]	Rate of Application[52]	EIQ Field Use Rating
Imazapyr	2257	53	.6	6
2,4-D	809	87	2.4	**39**
Triclopyr	2170	62	2.5	**13**
Mancozeb	211	75	1.3	**15**
Oryzalin	1868	41	1.7	**13**
Oxyfluorfen	1973	22	.4	3
Simazine	531	42	1.6	10
Glyphosate	1855	41	1.3	8

Based on the EIQ field use ratings, the chemicals of greatest concern include 2,4-D, Mancozeb, Oryzalin, and Triclopyr. In choosing which of these three to focus on for educational materials, the consistency in use from 2000-2003 was evaluated. The application of 2,4-D has been traced to Barnum Timber. Their usage of the pesticide has been inconsistent due to the selling of their lands in recent years, therefore the educational materials developed will focus on Triclopyr used in the timber industry, and Mancozeb and Oryzalin used in the wine grape industry.

Focus on Education & Reduction of Use

A clear basis for promoting education and understanding of the most widely applied pesticides within the two largest economic industries in Mendocino County is to better safeguard the health of residents in Mendocino County and our environment.

Most of the health effects from applying pesticides take place upon application. For example, recognizing the effects of say 2,4-D on reproduction and sperm count may generate greater care and awareness when applying these pesticides. Similarly, by understanding the ecological effects, those businesses choosing to use the chemicals may be prompted to find less toxic alternatives and/or reduce use of the chemicals altogether.

Any campaigns initiated to reduce individual pesticide use in Mendocino County need to begin with a comprehensive assemblage of the users. Eventually, the drive to reduce pesticides, particularly the eight identified within this report, will require ongoing discussions with the businesses using the pesticides, providing alternatives or less toxic pesticides, and perseverance. See Table 4. for primary users in Mendocino County of eight pesticides illuminated in this report.

Table 4: Primary Users of Pesticides of Greatest Use by Volume in Mendocino County*

Imazapyr	2,4-D	Triclopyr	Mancozeb	Oryzalin	Oxyfuorfen	Simazine	Glyphosate
Mendocino Redwood Co.	Barnum Timber	Barnum	Hildreth	Brutocao	Jepson	Gary Dodd	Kendall Jackson
Campbell		Campbell	Norgard	Chevalier	Mendocino Hill	Brutocao	Madrigal

			Madrigal	Redwood Grove	Milovina Brothers	Vimark	Hildreth
			Keith Thornton	Richard Datra	Middle Ridge	Bartlomei Bros.	Milovina Bros.
			Pallini	Jack Cox	Welch Vineyard	Dan Waddington	Thomas Bros.

* This information was provided by staff of the Mendocino Department of Agriculture. The table is not comprehensive nor is the order of listing reflective of greatest use.

Conclusion

An ounce of prevention is worth a pound of cure. And, the surest method towards reducing risk to the environment and human health is to focus on reductions of pesticides. However, appealing for a reduction in use pound for pound is insufficient unless the campaign is coupled with less toxic sustainable alternatives. The ultimate goal is to reduce reliance on synthetic pesticides and transition Mendocino County agriculture towards ecologically sound and less toxic methods.

The state and federal policies pertaining to pesticide use provide limited progress towards reducing the use of hazardous pesticides. At the county level, a guided strategy could be developed to assist pesticide users in transitioning to environmentally benign pest control practices. Such a strategy includes educating the public about the risks to health and the environment from the use of synthetic pesticides as well as working directly with users through dialogue and training to quantifiably reach pesticide reduction targets.

Appendix A: Understanding the Physical Properties of Pesticides

Water Solubility

The water solubility of a pesticide is a measure of how readily the chemical will dissolve in water and is typically expressed as the maximum amount of the pesticide that will dissolve in one liter of water. Typical concentration units are mg per liter (mg/L) which is approximately equal to parts per million (ppm) or micrograms per liter (ug/L), which is approximately equal to parts per billion (ppb). The larger this number is, the more water soluble the pesticide, and the more readily the pesticide will be transported away from the application site by stormwater or irrigation water runoff. The California Department of Pesticide Regulation has determined that pesticides with a water solubility greater than 3 mg/L have potential to contaminate groundwater. In reality, pesticides with water solubilities less than 3 mg/L have been found in groundwater, so this is no guarantee.

Half-Life

Half-life is defined as the time (in days, weeks or years) required for half of the pesticide present after an application to break down into degradation products. This time is often expressed as a range (for example, 1-3 days, 2-4 years, etc.) because the rate of pesticide breakdown depends on a variety of factors including temperature, soil pH, soil microbe content and whether or not the pesticide is exposed to light, water and oxygen. It is worth noting that many of the breakdown products themselves are toxic and may have significant half-lives as well. There are several different types of half-lives:

- **Soil half-life:** The amount of time required for half of the pesticide to degrade in soil. This half-life is governed by the types of soil organisms that are present that can break down the pesticide, the soil type (e.g., sand, loam, clay), pH, and temperature. The California Department of Pesticide Regulation has determined that pesticides with an aerobic soil half-life greater than 690 days or an anaerobic soil half-life greater than 9 days have potential to contaminate groundwater.
- **Photolysis half-life:** The amount of time required for half of the pesticide to degrade from exposure to light. The California Department of Pesticide Regulation has determined that pesticides with a hydrolysis half-life greater than 14 days have potential to contaminate groundwater.
- **Hydrolysis half-life:** The amount of time required for half of the pesticide to degrade from reaction with water. The California Department of Pesticide Regulation has determined that pesticides with a hydrolysis half-life greater than 14 days have potential to contaminate groundwater.

Adsorption Coefficient, K_{oc}

The adsorption coefficient, K_{oc}, is a measure of how strongly a chemical adheres to soil in preference to remaining dissolved in water. In more general terms, this parameter is often called K_d, a distribution coefficient that provides a measure of how a substance is distributed between any two different media--air/water, water/soil, or two different immiscible solvents.

K_{oc} is formally defined as the ratio of the mass of pesticide adsorbed per unit mass of soil to the mass of the pesticide remaining in solution at equilibrium. Because it is a ratio of masses, the number is unitless. The value is dependent on the type of soil and the soil pH, so it is not uncommon to see a range of values reported in the literature.

Pesticides with high K_{oc} values are typically not very water soluble and will preferentially adhere to soils rather than be dissolved in water. This means that pesticides in this class are unlikely to be carried off-site in runoff as dissolved substances; instead, they are transported on sediment particles. For some example values consider DDT with a K_{oc} of 100,000 (adheres strongly to soil). Diazinon has a K_{oc} of 1,580 and is readily transported as the free substance dissolved in water. The California Department of Pesticide Regulation has determined that pesticides with a K_{oc} less than 1,900 have potential to contaminate groundwater.

Octanol-Water Partition Coefficient, K_{ow}

The octanol-water partition coefficient, K_{ow}, is a measure of how a chemical will distribute between two immiscible solvents--water (a polar solvent) and octanol (a relatively non-polar solvent). The K_{ow} value provides information on the polarity of the pesticide and is often used as a model for how the pesticide may be distributed in body tissues, e.g. blood vs. fat tissue. Pesticides with a long half-life and high K_{ow} have been shown to bioaccumulate in the food chain.

In more general terms, this parameter is often called K_d, a distribution coefficient that provides a measure of how a substance is distributed between any two different media--air/water, water/soil, or two different immiscible solvents.

K_{ow} is formally defined as the ratio of the concentration of pesticide in the octanol layer to the concentration of the pesticide dissolved in the water layer. Because it is a ratio of concentrations, the number is unitless. The value is dependent on temperature.

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[1] Pimental, D. et al. Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. *BioScience* 2005;Vol. 55.7:573-582.

[2] Naylor, R. and P.R. Ehrlich. Natural Pest Control Services and Agriculture. In *Nature's Services*, Edited by Gretchen Daily (Washington, D.C.: Island Press, 1997).

[3] Pimental and Levitan, 1988

[4] Pimentel, D. and Levitan, L. Pesticides: amounts applied and amounts reaching pests. *Bioscience* 1986*;* 36, 86-91.

[5] Naylor, R. and P.R. Ehrlich. Natural Pest Control Services and Agriculture. In *Nature's Services*, Edited by Gretchen Daily (Washington, D.C.: Island Press, 1997).

[6] Repetto and Baliga, 1996

[7] Pimental D, Acquay H, Biltonen M, Rice P, Silva M, al. Environmental and economic costs of pesticide use. *BioScience* 1992; 42:750-759.

[8] Pimental, D. *Environmental and Economic Costs of the Recommended Applications of Pesticides. Environment, Development, and Sustainability*. 2005, Forthcoming.

[9] Significance is measured by a pesticides rate of use in pounds of active ingredient, its ability to enter groundwater and surface water, the chemical's persistence in the environment, its health effects including potential carcinogenicity and neurotoxicity to humans, and sublethal and acute effects on wildlife, plant species, and beneficial organisms. In addition, the Environmental Impact Quotient has been used to identify the most toxic pesticides. This formula and its use will be fully explained within this report.

[10] This figure includes approximately 602,000 pounds of sulfur.

[11] USEPA. Office of Pesticide Programs. 1987. EEB Review of 241-EEO. Washington, DC (April 21 & June 1).

[12] USEPA-OPP. 1984. Memo from S. Creeger, Hazard Evaluation Division to R. Taylor, Registration Division.

[13] Fowlkes MD, Michael JL, Crisman TL, Prenger JP. Effects of the herbicide imazapyr on benthic macroinvertebrates in a logged pond cypress dome.

[14] Kenigsberg, Y.E. 1968. Myotonia simulation in rats induced by the diethylamine salt of 2,4-dichlorophenoxyacetic acid. *Dokl. Akad. Nauk. Beloruss* 1968;12:473-475.

[15] Beasley, V.R. et al. 2,4-D toxicosis I: A pilot study of 2,4-dichlorophenoxyacetic acid- and dicamba-induced myotonia in experimental dogs. *Vet. Hum. Toxicol*. 1991; 33:435-440.

[16] Lerda, D. and R. Rizzi. Study of reproductive function in persons occupationally exposed to 2,4-dichlorophenoxyacetic acid (2,4-D). *Mut. Res.* 1991; 262:47-50.

[17] Zahm, S.H. et al. A case-control study of non-Hodgkin's lymphoma and the herbicide 2,4- dichlorophenoxyacetic acid (2,4-D) in eastern Nebraska. *Epidemiology* 1990; 1:349-356.

[18] Roberts, B.L. and H.W. Dorough. Relativetoxicities of chemicals to the earthworm Eisenia foetida. *Environ. Toxicol. Chem*. 1984; 3:67-78.

[19] FInlayson, B.J. and K.M. Verrue. Toxicities of butoxyethanol ester and propylene glycol butyl ester formulations of 2,4-dichlorophenoxyacetic acid (2,4-D) to juvenile salmonids. *Arch. Environ. Contam. Toxicol.* 1985; 14:153-160.

[20] Cryer, S.A. et al. 1993. The dissipation and movement of triclopyr in a Northern U.S.A. forest ecosystem. DowElanco. Study No:PM91-2502. Data package Report No. ABM-143895-E. DPR# 51566-021.

[21] U.S. EPA. Prevention, Pesticides and Toxic Substances. 1998. Reregistration eligibility decision(RED): Triclopyr. Washington, D.C., October.

[22]U.S. Geological Survey. 1999. Pesticides detected in urban streams during rainstorms and relations to retail sales of pesticides in King County, Washington. USGS Fact Sheet 097-99. Tacoma WA, Apr. 69. Rashin, E, and C. Graber.

[23] U.S. EPA. Prevention, Pesticides and Toxic Substances. 1998. Reregistration eligibility decision(RED): Triclopyr. Washington, D.C., October.

[24] U.S. EPA. Prevention, Pesticides and Toxic Substances. 1998. Reregistration eligibility decision (RED): Triclopyr. Washington, D.C., October.

[25] U.S. EPA. Prevention, Pesticides and Toxic Substances. 1998. Reregistration eligibility decision (RED): Triclopyr. Washington, D.C., October.

[26] Perkins, Peggy J.; Boermans, J. Herman; Stephenson, R. Gerald: Toxicity of Glyphosate and Triclopyr Using the Frog Embryo Teratogenesis Assay-Xenopus; Environmental Toxicology and Chemistry, Vol. 19, No. 4, pp. 940-945, 2000

[27] U.S. EPA. Prevention, Pesticides and Toxic Substances. 1998. Reregistration eligibility decision (RED): Triclopyr. Washington, D.C., October.

[28] Morgan, J.D. et al. Acute avoidance reactions and behavioral responses of juvenile rainbow trout (Oncorhynchus mykiss) to Garlon 4A®, Garlon 3A®, and Vision® herbicides. *Environ. Toxicol. Chem.* 1991; 10:73-79.

[29] Shukla, Y. & A. Arora. Transplacental carcinogenic potential of the carbamate fungicide mancozeb. *Environ Pathol Toxicol Oncol*. 2001;20(2):127-31.

[30] U.S. Environmental Protection Agency. Pesticide Fact Sheet Number 125: Mancozeb. Office of Pesticides and Toxic Substances, Washington, DC, 1987.4-10

[31] Hall, LC, JM Rogers, MS Denison, ML Johnson. Identification of the herbicide Surflan and its active ingredient oryzalin, a dinitrosulfonamide, as xenoestrogens.
Arch Environ Contam Toxicol. 2005 Feb;48(2):201-8.

[32] U.S. EPA. Prevention, Pesticides and Toxic Substances.1994. Reregistration eligibility decision(RED): Oryzalin. www.epa.gov/pesticides. .

[33] US. Environmental Protection Agency. June 20, 1990. Pesticide tolerance for oryzalin. Federal Register 55 (119): 25140-1.

[34] U.S. EPA. Prevention, Pesticides and Toxic Substances.1994. Reregistration eligibility decision(RED): Oryzalin. www.epa.gov/pesticides..

[35] U.S. Geological Survey. National Water-Quality Assessment (NAWQA) Program. 1998-2000. Circulars 1144, 1150, 1151, 1155-1171, 1201-1216. http://water.usgs.gov/pubs/nawqasum/.

[36] U.S. EPA. Prevention, Pesticides and Toxic Substances.1994. Reregistration eligibility decision(RED): Oryzalin. www.epa.gov/pesticides.

[37] USEPA, OPPTS,Revised Environmental Fate and Effects Division Preliminary Risk Assessment for the Oxyfluorfen Reregistration Eligibility Decision Document. 11 December 2001.

[38] Spurlock, F., Burow, K., and Dubrovsky, N. Chlorofluorocarbon dating of herbicide-containing well waters in Fresno and Tulare counties, California. *J.Environ*. 2000; Qual. 29: 474-483.

[39] Holden, L. R., Graham, J. A., Whitmore, R. W., Alexander, W. J., Pratt, R. W., Liddle, S. K., and Piper, L. L. Results of the National Alachlor Well Water Survey. *Environ. Sci. Technol*.1992; 26 (5): 935-943.

[40] Habecker, M. A. Environmental Contamination at Wisconsin Pesticide mixing/loading facilities: Case study, investigations and remedial action evaluation. Wisconsin Department of

Agriculture, Trade and consumer Protection, Agricultural Resource management Division, Madison, WI. 1989. pp. 80.

[41] Lennartz, B., Louchart, X., Voltz, M., and Andrieux, P. Diuron and simazine losses to runoff water in Mediterranean vineyards. *J. Environ. Qual*. 1997; 26: 1493-1502.

[42] Louchart, X., Voltz, M., Andrieux, P., and Moussa, R. Herbicide transport to surface waters at field and watershed scales in a Mediterranean vineyard area. *J.Environ. Qual*. 2001; 30: 982-991.

[43] Sawada, Y., Y. Nagai, and I. Yamamoto. "Probably toxicity of surface-active agent in commercial herbicide containing glyphosate." *Lancet* 1994; 1:299.

[44] Richard, S**.**, et al. Differential Effects of Glyphosate and Roundup on Human Placental Cells and Aromatase *Environmental Health Perspectives* 2005;113.6.

[45] Rank, J. et al. Genotoxicity testing of the herbicide Roundup® and its active ingredient glyphoisate, using the bone marrow micronucleus test, salmonella mutagenicity test, and allium anaphase test." *Mutation Research* 1993;300.1:29-36.

[46] USEPA, Office of Pesticides and Toxic Substances, Health Effects Division, "Second Peer Review of Glyphosate," 30 October, 1991.

[47] Relyea, R.A. (2005) The lethal impact of Roundup® on aquatic and terrestrial amphibians. *Ecol. Appl*., In Press.

[48] J. Kovach, C. Petzoldt, J. Degni and J. Tette, *A Method to Measure the Environmental Impact of Pesticides*, New York's Food and Life Sciences Bulletin No. 139, Cornell University, Ithaca, NY, USA (1992), 8 pp.

[49] L. Levitan, I. Merwin and J. Kovach, "Assessing the Relative Environmental Impacts of Agricultural Pesticides: The Quest for a Holistic Method," *Agric., Ecosystems Environ 1995;* 55:153-168.

[50] State of California, Department of Pesticide Regulation. 2003 Pesticide Use Report Database. January 2005.

[51] State of California, Department of Pesticide Regulation. 2003 Pesticide Use Report Database. January 2005.

[52] State of California, Department of Pesticide Regulation. 2003 Pesticide Use Report Database. January 2005.