

***Measurement System Changes and  
Progress Toward Meeting WWF-WPVGA  
Pesticide Risk Reduction Goals:  
A Crop Year 1998 Status Report***

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## INTRODUCTION

This report provides an update of pesticide use, reliance and risk measurement activities carried out in 1998, as well as a status report on changes in Wisconsin potato pesticide use in crop season 1998. Since 1996 the World Wildlife Fund (WWF) and the Wisconsin Potato and Vegetable Growers Association (WPVGA) have been working on a collaborative project focusing on reducing pesticide reliance and risks through adoption of biointensive Integrated Pest Management<sup>1</sup> (IPM). A core project goal has been developing the measurement systems needed to convincingly demonstrate the linkage between progress along the IPM continuum and lessened reliance on high-risk pesticides.

The WPVGA represents about 250 growers accounting for nearly all potato production in the State. The association has played an active role for more than a decade in supporting IPM research and on-farm innovation designed to lessen the environmental effects of potato production systems. In June 1998, WPVGA received World Wildlife Fund's top honor, the "Gift to the Earth" award for its achievements in reducing use of high-risk pesticides between 1995 and 1997.

WWF is an international environmental organization working to protect endangered species, enhance wildlife habitat, and address global threats to biodiversity. Now in its fourth decade, WWF works in more than 100 countries around the globe and has over one million members in the United States.

From the beginning of the WWF-WPVGA collaboration, critical assistance and leadership has been provided by members of the University of Wisconsin (UW) potato IPM research and extension education team. UW scientists have served on the project advisory committee, helped develop and refine measurement methods, and actively assisted WWF and WPVGA encourage grower adoption of changes in pest management systems considered essential to meet industry-wide pesticide risk reduction goals.

As of April 1999, the University of Wisconsin is a member of the collaboration and continues to be represented on the project Advisory Committee, a broad stakeholder group.

Biointensive IPM in agriculture is defined as – "A systems approach to pest management that is based on an understanding of pest ecology. It relies on resistant varieties and promoting plant health, crop rotation, disrupting pest reproduction, and the management of biological processes to diversify and build populations of beneficial organisms. Reduced risk pesticides, including biopesticides, are used only as a last resort and only in ways to minimize risks."

## The Need for Credible Methods to Monitor Progress

Interest is growing worldwide in the potential of new technology to reduce the direct and indirect health and environmental costs associated with heavy reliance on pesticides. With increasing frequency, farmers, public institutions, and consumers are grappling with the pros and cons of alternate ways to improve the performance of farming systems, from genetic improvement and biotechnology, to novel biopesticides and biointensive IPM systems.

As new science, technology and product development broadens options on the farm, assessing the consequences of system changes becomes more complicated, and not just for farmers and pest management specialists. Regulators struggle to project the health and ecological impacts of new technology at the margins of risk assessment science, and consumers struggle to place into perspective the often widely conflicting information in the news about new agricultural technologies, especially those involving pesticide use or genetic engineering.

Measurement tools and systems are clearly not keeping pace. There is a critical need for better systems to objectively determine whether a given technology or farming system innovation

is improving or impairing resource and environmental quality, food safety, and the performance of farming systems. But who is to judge, and on what basis, whether a particular new technology is making matters better or worse, for whom, and at what cost?

In many countries, public and private organizations have initiated, or are participating in, programs designed to promote adoption of “greener” farming systems, often through adoption of IPM. Environmental and consumer groups, including the World Wildlife Fund, are exploring ways to promote and reward IPM adoption through marketplace initiatives (for a review of WWF’s involvement, see Hoppin, 1996). Yet questions remain and views differ regarding what constitutes “IPM” and whether IPM will marginally or significantly contribute to gains in environmental quality.

Our project seeks to produce a body of information on changes in Wisconsin potato IPM and pesticide use that is sufficiently detailed to establish the linkages between progress along the IPM continuum and lessened reliance on high-risk pesticides. In 1998, progress was made in refining the analytical tools we will use in achieving this goal.

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## ***Reasons to Monitor Pesticide Use and Risks and Measure IPM Adoption***

Improved measures of pesticide use and reliance, linked to measures of IPM adoption, are needed to keep pace with rapid on-farm innovation in the design and implementation of preventive pest management systems. Several factors have worked together to fuel innovation in the Wisconsin potato industry –

- A successful industry-wide effort in the late 1980s made it possible to phase out use of the highly toxic insecticide aldicarb when potentially dangerous levels were found in drinking water in some potato producing areas of the state;
- A major and largely successful commitment has been made, and is ongoing to avoid the emergence of resistance to both promising new and still-valuable older pesticides;
- Diagnostic tools and phenology-based crop growth, fertilization, irrigation and pest management models, especially the “WISDOM” system, have become critical, widely used resources to sharpen on-farm management skills;
- The discovery of promising biopesticides and other lower-risk pesticides has given growers key new control options;
- New IPM techniques are emerging like area-wide management to suppress populations and ways to augment soil microbial activity;
- Grower commitment has always been strong to enhance wildlife habitat and improve water quality; and
- There has been widespread support for an effort to get “ahead of the curve” as the Environmental Protection Agency (EPA) implements the “Food Quality Protection Act of 1996” (FQPA).

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From the outset of this project, the project team has worked to overcome the limitations of two traditional measures of pesticide use – pounds of active applied per acre and number of applications. These indicators of use are reliable only if most pesticides have comparable impact per pound applied and per acre treated. We know this is certainly not the case.<sup>ii</sup> A review of several efforts to develop new measurement tools appears in *Pest Management at the Crossroads*<sup>iii</sup> (PMAC); the

PMAC website contains several documents describing and critiquing various risk index and indicator methodologies. (<http://www.pmac.net/measind.htm>)<sup>iv</sup>

Improved measurement methods are needed to resolve how to work through tradeoffs between environmental protection, public health, and crop production efficiency and costs.

Such tradeoffs are inherent outcomes whenever changes occur in pest management systems and technology. The pros and cons of system changes are increasingly complex to sort out, even for technical experts and the most experienced and intuitive farmers. This reality explains, in part, the high level of interest of Wisconsin growers in this project and the new sorts of information

and insights it is generating. Farmers recognize that alternative approaches to pest management pose new risks, create opportunities to lower costs (or increase losses), and create need for new sources and types of information. Finding ways to develop and provide such information to growers as they progress along the IPM continuum remains a basic goal of the WWF/WPVGA potato IPM project.

Farmers recognize that alternative approaches to pest management pose new risks, create opportunities to lower costs and create need for new sources and types of information.

## **CHANGES IN ESTIMATES OF PESTICIDE TOXICITY ADJUSTMENT FACTOR VALUES**

The project uses pesticide active ingredient-specific “toxicity adjustment factor values” to convert the pounds of different pesticides applied to a common measure of potential impact – what we call “toxicity units.” The toxicity units associated with use of pesticide X is the pounds of pesticide X applied multiplied by pesticide X’s toxicity factor value. Others call similar measures for a given active ingredient “impact quotients” or “environmental impact points.”

Toxicity factor values are also used to construct various relative rankings of potential risk or impact. The values themselves are a sort of relative risk index. As such, toxicity factor values are akin to a way to mix “apples and oranges” in an analysis of fruit consumption.

Consider an analogy to the way consumers choose from among many gasoline products. Once at the pump, octane ratings and price generally determine a consumer’s choice. But octane ratings are just one of many different ways to rate the performance and quality features of different liquid fuels. If the focus is horsepower and energy output, one set of measures will be most useful; if the focus is air quality impacts, or potential damage to engines, other sets of measures will provide more reliable and effective perspective on tradeoffs. The same is true with pesticides. The “toxicity factor values” used in a given assessment need to be developed to match the human health, environmental, or on-farm impacts of most immediate concern. The reliability of the information gained will be a

function of how well toxicity factor values actually capture the true differences across pesticides.

Toxicity adjusted pesticide use estimates need to be dynamic. As new products are registered, and better information emerges on potential impacts, the system must accommodate new information smoothly and in a transparent way. The ideal system offers a structured framework in which to pose and answer questions about the impacts of changes in pest management systems and trends in IPM innovation.

Measurement tools should support assessment of different categories of pesticide risks, singly or in combination, or the practices and pesticides needed to deal with a given pest like the Colorado potato beetle, or sets of pests, i.e. all weeds or blight diseases. In general, the broader the application, the more challenging the task of coming up with indicators that are equally applicable to different circumstances.<sup>v</sup>

One key point deserves emphasis - there is no one “right way” to construct and use toxicity adjustment factors. Most risk indices are too crude to distinguish reliably between two pesticides that are closely related and cause comparable effects at similar dose rates. Risk indices are most reliable and useful in monitoring changes in average levels of toxicity over time, and in comparing the toxicity and risks associated with groups of pesticides. Such comparisons provide insights into the magnitude of environmental and public health gains possible from progress along the IPM continuum.

During the April 1999 project advisory committee meeting in Madison, Wisconsin, several clarifications and technical refinements were discussed and agreed upon in the project's measurement methods, along with the way the project sets and will monitor progress toward pesticide risk reduction goals. This section briefly describes the changes made and now incorporated in the toxicity factor values underlying the findings reported herein.

Appendix 1 summarizes, in more detail by active ingredient, all changes

## **1. Industry-wide toxicity units will be used to set goals and monitor progress toward specific pesticide risk reduction goals.**

Risk reduction goals are set on an industry-wide basis, encompassing all potato growers in the state. Progress toward specific reduction targets will be monitored using average toxicity units per

made in the four major component indices – acute mammalian toxicity, chronic mammalian, ecotoxicity, and BioIPM components – that are part of the WWF-WPVGA multiattribute index. The appendix includes tables showing the toxicity factor values used in setting the 1995 baseline and in calculating crop year 1997 toxicity units, as well as the new factor values relied upon in 1998. In most cases the differences are modest, especially in final multiattribute factor values where relatively low weight is given to any single component or change.

acre across the industry, not just pounds applied. Using per acre averages will assure that the attainment of a goal is not influenced by normal, year-to-year variation in the acres of potatoes planted.

## **2. In addition to acute and chronic risk reduction goals, we will also monitor progress in reducing the toxicity units per acre from herbicides, insecticides and fungicides combined.**

The project Memorandum of Understanding (MOU) sets forth three risk reduction goals from the crop year 1995 baseline: the first applied to pesticide use in 1997, the second applies to crop season 1999, and the third, crop year 2001. (For more detail, see <http://www.pmac.net/pusered.htm>).

Table 1 sets forth the goals applicable to pesticides triggering the acute toxicity and chronic toxicity criterion for falling under the MOU's risk reduction goals. It also shows preliminary goals for reduction in combined toxicity units from herbicides, insecticides, and fungicides combined.

An important note – WWF-WPVGA industry-wide pesticide use goals and risk reduction targets apply only to

herbicides, insecticides and fungicides used to control pests during the production season. We do not include a number of pesticides classified by USDA as "Other Pesticides." These include pre-plant soil fumigants, desiccants and other materials used to kill potato vines, or post-harvest compounds used in storage facilities. In addition, "Other Pesticides" include active ingredients like 2,4-D and diquat, which are used in the Wisconsin potato industry for vine kill late in the season, not as a herbicide pre- or at planting time as they are on many other farms.

We choose not to include "Other Pesticides" in project goals for two reasons. Several "Other Chemicals" are used to kill potato plants later in the season, to facilitate harvest. These

applications do not involve management of a pest and hence reliance on them cannot be reduced through bio-intensive IPM.

Soil fumigants compose most other applications of “Other Chemicals.” We excluded these because of the lack of options when verticillium levels exceed the threshold in the soil profile. In addition,

most fumigants are applied in very large volumes – often over 100 pounds of active ingredient per acre – once every five to ten years. If we included these pounds applied in our measurement of pesticide use, the fields treated with a fumigant in a given year would have grossly skewed values.

<b>Table 1. WWF-WPVGA Toxicity Unit Reduction Goals by Category of Risk Criterion for Eleven Targeted Pesticides</b>			
	<b>1997</b>	<b>3-Year Goal; Crop Season 1999</b>	<b>5-Year Goal; Crop Season 2001</b>
<b>Risk Criterion:</b>			
Acute Risk	25%	50%	100%*
Chronic Risk	15%	30%	100%*
<b>Combined Goal</b>	20%	40%	100%*
*Use of active ingredients shall be phased out or an agreed upon third party will certify there are no residues in food or the environment at levels of concern.			

### **3. Update the list of pesticides known to disrupt the endocrine system.**

Since the “Preliminary Pest Management Goals” were set, several additional pesticide active ingredients have been added to the list of endocrine disruptors maintained by the WWF Wildlife and Contaminants Program. The MOU anticipated this prospect, and states that new active ingredients should be added to the list of pesticides triggering risk reduction targets if new evidence warrants classification as either an acute or chronic risk, based on the original criteria set forth in the MOU. Seven new active ingredients trigger the endocrine disruptor criterion: metiram, linuron, pendimethalin, dimethoate, esfenvalerate, piperonyl butoxide, and pyrethrins.

The project Advisory Committee has not yet finalized how to incorporate these seven new active ingredients in monitoring attainment of the project’s crop year 1999 and 2001 risk reduction goals. Doing so raises a number of

analytical issues since it is important to assure that pesticide use and toxicity units in 1995 – the baseline year – and 1999 and 2001 are calculated using a consistent set of factors. This will require some adjustment of baseline toxicity unit calculations since we will continuously update and refine toxicity factor values as better data become available. So, in the context of the data presented herein, adding the seven new active ingredients to the list of endocrine disrupting chemicals has two consequences.

First, in the calculation of the pesticide’s Mam Tox Score, our basic measure of chronic toxicity, there is an added three-fold safety factor included in the formula.<sup>vi</sup> See below and Appendix 1 for an explanation of all changes made in each of the four major components of the WWF-WPVGA multiattribute toxicity index, which includes Mam Tox Score.

The second consequence is small changes in the industry-wide toxicity unit baseline for crop year 1995, as well as changes in toxicity unit calculations in 1997 and 1998 because of the changes in the Mam Tox Score factor for these seven pesticides. In all the tables that follow, we use the updated multiattribute toxicity

factor values to calculate toxicity units. The changes are modest but needed in order to provide a statistically consistent basis for assessing trends in per acre toxicity units that reflect real changes in pesticide use patterns, not just changes in the way we calculate toxicity units as more and better data become available.

#### **4. Update Mam Tox Score Chronic Mammalian Toxicity Factor Values.**

For all active ingredients used from 1995 through 1998, we have calculated updated Mam Tox Score values using the most recently available EPA chronic Reference Dose, cancer classification and Q\*s, and the updated list of endocrine disruptors. Nine active ingredients were reported as used in Wisconsin potato production in 1998 that were not used in 1995 or 1997. Two were newly registered fungicides, and seven were long-registered compounds that just had not been used in recent years by Wisconsin potato producers.

For these nine pesticides we calculated new Mom Tox Score values. The only other change in chronic mammalian toxicity factor values result from dropping the water leaching scaling factor used in setting the 1995 baseline. We also dropped this scaling factor from our estimates of acute mammalian toxicity. This scaling factor was based on the National Resources Conservation Service (NRCS) "Sci-Grow" model for projecting the potential of a pesticide to leach to groundwater. This particular

model is no longer used or supported by NRCS, and better methods are emerging to establish water leaching potential scaling factors. Once a consensus emerges regarding the appropriate method to develop such a scaling factor, it will be included in future estimates of toxicity factor values.

In the longer-run, further changes will no doubt be made in the chronic toxicity component of the project's multiattribute toxicity unit equation. EPA is making progress in reviewing and adjusting Reference Doses for major pesticides under the Food Quality Protection Act. We are working updated values into the database as decisions are finalized. Within the next 12 months, EPA is likely to review and revise perhaps as many as one-third of current RfDs. We also anticipate changes in how a pesticide's ability to disrupt the endocrine system will be taken into account in the Mam Tox Score formula. It is realistic to plan for incorporation of a new formula in the chronic toxicity component for year 2001 applications.

#### **5. Update Ecotoxicity Values.**

A major improvement has been made in ecotoxicity factor values, made possible by the availability of much improved avian toxicity values. Benbrook Consulting Services obtained the updated avian toxicity factors from Dr. Pierre Mineau, through an Alton Jones Foundation grant supporting the

Consumers Union FQPA project. Detailed documentation of the improved avian toxicity factor values is set forth in the paper, "Unbiased Reference Values for Acute Toxicity to Birds," by Dr. Pierre Mineau, Dr. A. Baril, Dr. B. Collins, and Dr. J. Duffe of the Environment Canada National Wildlife Research Centre in Hull,

Quebec. This technical methodology paper was done for Consumers Union, and will soon be accessible on the Consumers Union FQPA project website. (<http://www.ecologic-ipm.com>)

Changes in avian toxicity factor values were significant for some active ingredients, as apparent in the Appendix table covering changes in the ecotoxicity

## **6. Update BioIPM Values.**

Refined bee toxicity data have been incorporated in the BioIPM index. The data were obtained from the Dutch pesticide regulatory agency, and are considered the definitive bee pesticide toxicity data by international pesticide experts.

We also have updated the estimates of the propensity of pesticides to trigger resistance. In the case of herbicides, we reviewed the data on documented cases of weed resistance on the “Herbicide Resistant Weeds” website (<http://www.WeedScience.com>), maintained by the Weed Science Society of America. Based on the relative lack of evidence of resistant species in Wisconsin and the absence of a science-based method to refine herbicide resistance toxicity factors, we retained the values originally set by the UW IPM team. Work is ongoing to develop a better method to

## **7. Recalculated Multiattribute Toxicity Factor Values.**

Based on the above changes, we have recalculated each active ingredient-specific toxicity factor value using the previously agreed upon set of weights for the four major component indices. The WWF-WPVG formula will continue to be used in calculating active ingredient toxicity factor values and industry-wide toxicity units.

index. The score of most organophosphates rise as a result of updated avian data. There is little change in the values of key fungicides, with the exception of triphenyltin hydroxide (SuperTin). A large jump in the avian toxicity value for SuperTin raised the overall ecotoxicity score from 78.7 to 118.2.

estimate herbicide resistance management values.

In the case of insecticides and fungicides, we incorporated information on an active ingredient’s soil and leaf half-lives, as well as mechanistic information to produce a more empirical basis for the resistance values estimated in 1996-1997. See Appendix 1 for the details of changes made.

Additional literature review and expert guidance is required in setting BioIPM factor values for beneficial arthropods, worms and soil microorganisms. It will be years before there are an adequate range of test protocols to substantiate the impacts of pesticides on key BioIPM factors. In the interim, we will continue to rely on expert judgment and the spotty data that is available.

Table 2 presents the 1998 component values used for all active ingredients used in 1995, 1997, or 1998 in Wisconsin potato production. It also shows the final multiattribute toxicity factor values used throughout this report in calculating toxicity units. The last two columns of the table show the toxicity factor values used in past analyses and the percentage change in the multiattribute toxicity factor values.

**Table 2. Component and Multiattribute Toxicity Factor Values for Pesticides Used in Wisconsin Potato Production**

WWF-WPVG Multiattribute Formula = (0.5)*Acute + (1.0)*Chronic + (1.0)*EcoTox + (1.5)*BioIPM								
Active Ingredient	AI Type	Acute Index	Chronic Index	EcoTox Index	BioIPM Index	1998 Multiattribute Index	1995-1997 Multiattribute Index	Percent Change 1995-1998
2,4-D	H	1.3	30.0	2.6	41.2	95		
alachlor	H	0.5	30.0	1.2	51.2	108		
azinphos-methyl	I	31.3	66.7	29.8	130.0	307	220	40%
azoxystrobin	F	0.1	0.6	41.3	34.8	94		
basic copper sulfate	F	0.2	0.3	8.1	22.8	43		
chlorothalonil	F	0.1	8.9	27.8	30.0	82	80	2%
copper ammonium	F	1.7	0.3	1.8	29.6	47	47	1%
copper hydroxide	F	0.5	0.3	2.5	29.7	48	52	-8%
copper resinate	F	0.1	0.3	1.8	29.7	47	51	-8%
copper sulfate	F	1.7	0.3	2.5	22.8	38	42	-10%
cymoxanil	F	0.5	6.3	1.4	27.8	50	62	-20%
dimethoate	I	3.3	200.0	15.2	92.3	355	314	13%
dimethomorph	F	0.1	10.0	12.4	21.6	55		
diquat	H	2.2	45.5	16.9	26.7	103	88	18%
disulfoton	I	192.3	200.0	36.4	138.9	541		
endosulfan	I	6.3	50.0	118.4	66.3	271	289	-6%
endothal	H	9.8	5.0	10.3	26.8	60		
esfenvalerate	I	7.5	5.0	200.0	182.1	482	398	21%
ethoprophos	I	19.2	200.0	13.0	77.6	339	320	6%
fonofos	I	62.5	50.0	28.8	64.4	207	188	10%
glyphosate	H	0.1	0.1	1.3	51.0	78	78	0%
imidacloprid	I	1.1	1.8	3.6	200.0	306	248	23%
linuron	H	0.1	12.5	6.2	39.1	77	73	6%
malathion	I	0.2	7.5	0.4	82.8	132		
maleic hydrazide	O	0.1	0.4	1.4	26.7	42	58	-28%
mancozeb	F	0.1	130.0	2.2	43.5	197	180	10%
maneb	F	0.1	90.0	8.0	42.9	162	154	5%
metalaxyl	F	0.7	1.4	3.4	113.0	175	172	2%
metam sodium	O	1.8	109.0	7.7	58.5	205	187	10%
methamidophos	I	16.7	100.0	18.4	74.6	239	200	19%
metiram	F	0.1	200.0	1.3	33.0	251	250	0%
metolachlor	H	0.2	1.0	1.5	30.4	48	46	5%
metribuzin	H	0.2	23.1	7.2	64.7	127	127	0%
paraquat dichloride	H	3.3	22.2	3.7	52.5	106	91	17%
pendimethalin	H	0.5	2.3	10.9	78.9	132	167	-21%
permethrin	I	1.0	10.6	41.5	156.8	288	265	9%
phorate	I	200.0	200.0	180.6	96.4	625	566	10%
phosmet	I	2.2	33.3	24.2	49.9	133		
piperonyl butoxide	I	0.1	17.1	0.2	27.9	59	49	21%
propamocarb hydro.	F	0.1	1.0	0.9	32.4	51	51	-1%
pyrethrins	I	0.3	4.7	11.1	126.0	205	100.4	104%
rimsulfuron	H	0.1	6.3	1.9	96.4	153	90	70%
sethoxydim	H	0.2	1.1	0.6	48.4	74	61	22%
sulfuric acid	O	0.5	0.3		18.8		21	0%
triphenyltin hydroxide	F	3.2	200.0	118.2	43.2	385	338	14%

## **PESTICIDE USE AND TOXICITY UNITS: INDUSTRY-WIDE TOTALS FOR 1995, 1997 AND 1998**

Newly calculated pesticide active ingredient multiattribute toxicity factor values were used to estimate the toxicity units associated with the use of all herbicides, insecticides and fungicides applied in producing potatoes in 1995, 1997, and 1998. For a given pesticide, the toxicity units are pounds applied multiplied by the pesticide's toxicity factor value.

Table 3 presents the results for 1995, the baseline year, as well as 1997 and 1998. For each year and active ingredient, we report acres treated, pounds applied, and toxicity units. Data on pesticide use are derived from surveys conducted by the National Agricultural Statistics Service (NASS), a part of USDA.

Appendix 2 presents detailed pesticide use tables for 1995, 1997 and 1998. Each reports percent acres treated, acres treated, average number of applications per acre, acre-treatments, average one-time rate of application, rate per crop year (one-time rate multiplied by the number of applications), and total pounds applied.

For each year, we also show totals by type of pesticide and per planted acre

averages. In calculating the per planted acre averages, we use total industry potato acreage, not just acres treated with a given pesticide, or any herbicide. Such an average is the best single measure of changes in the degree of reliance of Wisconsin potato growers on both all and high-risk pesticides. Toxicity units per planted acre corrects for any changes in the acres planted in a given year, and is the best indicator available of likely trends in the overall impact of pesticides on the environment in Central Wisconsin's potato production areas.

The last two rows of Table 3 aggregate herbicide, insecticide and fungicide data. Overall pounds applied dropped about three-quarters of a pound per acre from 1995 to 1997, but a big jump in insecticide use in 1998 accounted for a two-thirds pound per acre increase from 1997 to 1998. Increased use of endosulfan accounted for about half the 36,000 pound increase in insecticide use and most of the rest by an almost 12,000 pound increase in pounds applied of piperonyl butoxide, a synergist used in conjunction with synthetic pyrethroid insecticides.

Overall pounds applied dropped about three-quarters of a pound per acre from 1995 to 1997, but a big jump in insecticide use in 1998 accounted for a two-thirds pound per acre increase from 1997 to 1998.

**Table 3. Wisconsin Potato Pesticide Use and Toxicity Units: 1995, 1997 and 1998**

<b>Herbicides:</b>	<b>Toxicity Factor Value</b>	<b>1995 Acres Treated</b>	<b>1995 Pounds Applied</b>	<b>1995 Toxicity Units</b>	<b>1997 Acres Treated</b>	<b>1997 Pounds Applied</b>	<b>1997 Toxicity Units</b>	<b>1998 Acres Treated</b>	<b>1998 Pounds Applied</b>	<b>1998 Toxicity Units</b>
2,4-D	95.2	-	-	-	-	-	-	524	26	2,495
alachlor	108.2	-	-	-	-	-	-	10	19	2,101
glyphosate	77.9	6,640	4,000	311,420	7,800	9,000	700,694	11,138	6,222	484,396
linuron	77.3	7,470	7,000	541,064	5,460	3,000	231,884	13,245	14,214	1,098,658
metolachlor	48.3	14,940	21,000	1,013,330	4,680	7,000	337,777	9,422	6,302	304,082
metribuzin	127.4	73,870	39,000	4,968,192	72,540	34,000	4,331,244	56,147	35,868	4,569,246
pendimethalin	131.7	29,880	24,000	3,161,784	22,620	16,000	2,107,856	20,849	16,326	2,150,776
rimsulfuron	152.8	-	-	-	-	-	-	26,587	736	112,525
sethoxydim	74.4	8,300	2,000	148,843	-	-	-	5,235	982	73,095
<b>Total: All Herbicides</b>		<b>141,100</b>	<b>97,000</b>	<b>10,144,633</b>	<b>113,100</b>	<b>69,000</b>	<b>7,709,456</b>	<b>143,156</b>	<b>80,696</b>	<b>8,797,374</b>
<b>Per Planted Acre</b>		<b>1.7</b>	<b>1.2</b>	<b>122</b>	<b>1.5</b>	<b>0.9</b>	<b>99</b>	<b>1.8</b>	<b>1.0</b>	<b>113</b>
<b>Insecticides</b>										
azinphos-methyl	307.2	21,580	26,000	7,986,775	-	-	-	594	190	58,372
carbofuran	383.5	13,280	13,000	4,985,500	-	-	-	-	-	-
dimethoate	355.3	23,240	11,000	3,908,791	46,020	30,000	10,660,340	37,105	25,373	9,016,064
disulfoton	540.9	-	-	-	-	-	-	105	110	59,476
endosulfan	271.0	54,780	60,000	16,257,604	10,140	10,000	2,709,601	24,959	25,227	6,835,579
esfenvalerate	481.9	49,800	3,000	1,445,800	46,020	2,000	963,867	63,070	5,105	2,460,294
ethoprophos	339.0	-	-	-	-	-	-	950	2,850	966,355
fonofos	206.7	-	-	-	-	-	-	19	39	8,049
imidacloprid	305.9	-	-	-	36,660	8,000	2,446,960	33,972	7,322	2,239,519
malathion	132.3	-	-	-	-	-	-	1,752	491	64,896
methamidophos	238.6	53,950	69,000	16,464,923	17,160	17,000	4,056,575	18,975	19,164	4,572,987
oxamyl	282.0	6,640	5,000	1,410,000	-	-	-	-	-	-
permethrin	287.8	18,260	4,000	1,151,078	-	-	-	10,205	2,325	669,072
phorate	625.2	-	-	-	-	-	-	78	175	109,548
phosmet	133.5	-	-	-	-	-	-	5,498	3,489	465,563
piperonyl butoxide	59.1	14,110	3,000	177,444	17,940	7,000	414,035	31,050	18,898	1,117,774
pyrethrins	204.9	8,300	16	3,278	-	-	-	6,457	1,661	340,303
<b>Total: All Insecticides</b>		<b>263,940</b>	<b>194,016</b>	<b>53,791,193</b>	<b>173,940</b>	<b>74,000</b>	<b>21,251,377</b>	<b>234,788</b>	<b>112,419</b>	<b>28,983,852</b>
<b>Per Planted Acre</b>		<b>3.2</b>	<b>2.3</b>	<b>648</b>	<b>2.2</b>	<b>0.9</b>	<b>272</b>	<b>3.0</b>	<b>1.4</b>	<b>372</b>

Fungicides	Toxicity Factor Value	1995 Acres Treated	1995 Pounds Applied	1995 Toxicity Units	1997 Acres Treated	1997 Pounds Applied	1997 Toxicity Units	1998 Acres Treated	1998 Pounds Applied	1998 Toxicity Units
copper ammonium	47.3	-	-	-	-	-	-	1,850	363	17,159
azoxystrobin	94.1	-	-	-	-	-	-	19,654	2,399	225,770
basic copper sulfate	42.7	4,150	13,000	554,560	-	-	-	3,976	6,878	293,399
chlorothalonil	81.8	73,040	408,000	33,357,007	75,660	591,000	48,318,606	70,299	441,730	36,114,720
copper hydroxide	47.7	31,540	40,000	1,908,084	31,980	52,000	2,480,509	19,153	25,163	1,200,324
copper resinate	46.8	5,810	12,000	561,129	10,140	2,000	93,521	3,368	1,020	47,685
copper sulfate	37.8	-	-	-	7,020	8,000	302,427	1,259	606	22,913
cymoxanil	49.6	-	-	-	17,940	5,000	247,802	11,931	783	38,781
dimethomorph	55.0	-	-	-	-	-	-	2,667	551	30,310
mancozeb	197.5	71,380	412,000	81,355,826	52,260	287,000	56,672,626	64,663	438,986	86,684,698
maneb	162.3	11,620	76,000	12,338,435	16,380	62,000	10,065,566	3,438	8,050	1,306,937
metalaxyl	174.7	12,450	4,000	698,687	-	-	-	10,440	2,960	516,997
metiram	250.8	-	-	-	-	-	-	9,879	66,688	16,722,741
propamocarb hydro.	50.6	9,960	9,000	455,300	-	-	-	691	661	33,433
sulfur	68.2	-	-	-	-	-	-	1,850	2,395	163,417
triphenyltin hydroxide	384.7	38,180	12,000	4,615,905	36,660	8,000	3,077,270	36,825	10,521	4,046,823
<b>Total: All Fungicides</b>		<b>258,130</b>	<b>986,000</b>	<b>135,844,934</b>	<b>248,040</b>	<b>1,015,000</b>	<b>121,258,327</b>	<b>261,943</b>	<b>1,009,754</b>	<b>147,466,108</b>
<b>Per Planted Acres</b>		<b>3.1</b>	<b>11.9</b>	<b>1,637</b>	<b>3.2</b>	<b>13.0</b>	<b>1,555</b>	<b>3.4</b>	<b>12.9</b>	<b>1,891</b>
<b>Herbicides, Insecticides, and Fungicides</b>										
<b>Total: H+I+F</b>		<b>663,170</b>	<b>1,277,016</b>	<b>199,780,760</b>	<b>535,080</b>	<b>1,158,000</b>	<b>150,219,160</b>	<b>639,886</b>	<b>1,202,868</b>	<b>185,247,333</b>
<b>Per Planted Acre</b>		<b>7.99</b>	<b>15.39</b>	<b>2,407.00</b>	<b>6.9</b>	<b>14.8</b>	<b>1,926</b>	<b>8.2</b>	<b>15.4</b>	<b>2,375</b>
Source: Compiled by Benbrook Consulting Services based on potato use data from NASS/USDA, multiple years.										

Pounds of herbicide, insecticide and fungicide applied per acre industry-wide fell from 15.4 pounds in 1995 to 14.8 in 1997, but rose again to 15.4 in 1998 because of the increase in insecticide use. In terms of toxicity units, the big drop between 1995 and 1997 was largely erased. Industry-wide, toxicity units per acre fell from 2,407 in 1995 to 1,926 in 1997 and then went up to 2,375 in 1998.

<b>Industry-wide</b>	<b>1995</b>	<b>1997</b>	<b>1998</b>
Pounds of herbicide, insecticide, and fungicide per acre	15.4	14.8	15.4

<b>Industry-wide</b>	<b>1995</b>	<b>1997</b>	<b>1998</b>
Toxicity Units per acre	2,407	1,926	2,375

Compared to 1995, there was still a dramatic decrease in insecticide pounds applied and toxicity units. Industry-wide insecticide toxicity units fell 58 percent from 1995 to the 1997 season, from 648 toxicity units per planted acre to 272. Increased insecticide use in 1998 pushed toxicity units back up to an average of 372 per acre planted. Still, a reduction of 43 percent was achieved in 1998 compared to 1995. This level of reduction is, incidentally, very close to the crop year 1999 goal – a 50 percent reduction.

<b>Industry-wide</b>	<b>1995</b>	<b>1997</b>	<b>1998</b>
Insecticide Toxicity Units per acre planted	648	272	372

In terms of the share of total industry-wide toxicity units accounted for by herbicides, insecticides and fungicides in 1995, fungicides accounted for 68 percent of the total, insecticides about 27 percent, and herbicides about 5 percent. By 1997, the share of toxicity units accounted for by fungicides had risen to 81 percent, and remained at 80 percent in 1998. Clearly, further progress in the

## **Slippage in Progress Reducing Fungicide Toxicity Units**

Overall fungicide toxicity units per planted acre actually rose in 1998 compared to 1995, from on average 1,637 per planted acre in 1995 to 1,891 in 1998. Between 1995 and 1997 growers in the state had reduced fungicide toxicity units per acre about 5 percent - a significant accomplishment given that 1997 was a year with somewhat above average late blight disease pressure.

Three factors accounted for the slippage in 1998. First, an additional EBDC fungicide metiram was marketed aggressively in most potato growing areas and use rose from zero acres treated in

management of late blight diseases is among the most critical challenges if the Wisconsin, indeed the U.S. potato industry, is going to reduce its reliance on high-risk fungicide.

<b>Industry-wide</b>	<b>1995</b>	<b>1997</b>	<b>1998</b>
Percent of fungicides in total toxicity units	68%	81%	80%

While the new products will provide growers better options, a complete solution will entail much more. There is pressing need for the development of resistant varieties and the discovery of new area-wide strategies to suppress blight pressure, and to more aggressively deal with blight when and where it first appears. Further progress will depend upon the thoughtful, timely integration of a range of preventive and treatment options into well crafted, multi-tactic systems. There are a number of promising new technologies emerging that involve strengthening the plant's inherent ability to combat blight disease without loss of yield or product quality.

1995 or 1997 to almost 13 percent of acres treated. The 66,688 pounds applied of metiram added 16.7 million toxicity units to the industry-wide total, or some 11 percent. While there were almost 10,000 acres treated with metiram, use of maneb dropped by over 13,000 acres treated. But the metiram toxicity factor value of 251 is over 55 percent greater than maneb's value of 162.

This case of pesticide product substitution was no doubt driven in part by company pricing and marketing decisions. Since metiram is B<sub>2</sub> carcinogen, as are all other EBDC fungicides, metiram

will be subject to the chronic toxicity risk reduction goal in crop years 1999 and 2001.

<b>Industry-wide</b>	<b>1995</b>	<b>1997</b>	<b>1998</b>
Overall fungicide Toxicity Units per planted acre	1,637	1,555	1,891

Second, use of the EBDC fungicide mancozeb rose 53 percent in terms of pounds applied, adding over 30,000 toxicity units to the industry-wide total.

Third, the supplies in 1998 were still very limited of the new low-risk strobilurin fungicide azoxystrobin, or Quadris. This very promising new product was applied on less than 4,000 acres – far fewer than hoped by growers and industry leaders. The manufacturer was unable to gear up production and meet demand because of delays in receiving their final Section 3 registration from the EPA. In crop season 1999 the supply has increased appreciably and the acreage treated with this product is bound to rise markedly.

An acre treated with mancozeb or maneb accounts for about 225 toxicity units at a rate of about 1.25 pounds per application. Quadris, on the other hand, is applied at a rate of about 0.1 pounds per acre and contributes less than 10 toxicity units per acre treated – a 95 percent decrease in per acre toxicity units. It is for this reason that new chemistry can play such a profound role in achieving industry-wide risk reduction goals.

Dimethomorph is another promising new fungicide that is applied at about 0.2 pounds per acre, or 11 toxicity units per acre treated. A third new product is cymoxanil, which is applied at a rate of 0.07 pounds per acre, adding only 3.5 toxicity units per acre treated. In order to preserve the effectiveness of Quadris and other new fungicides, UW scientists are recommending close adherence to resistance management plans, which call for rotation in fungicides from different families of chemistry.

If growers could reduce mancozeb, maneb and metiram applications by 50 percent by switching three to five applications per acre to three promising new products registered recently, industry-wide fungicide toxicity units would as a result drop over 50,000 units – most likely more than enough to reach the 1999 chronic toxicity risk reduction goal of 25 percent compared to the 1995 level.

## AN UPDATE ON WWF-WPVGA RISK REDUCTION GOALS

WWF-WPVGA pesticide risk reduction goals seek to reduce reliance on, and use of both acutely and chronically toxic pesticides. Three tables follow that set forth the active ingredients triggering the acute and chronic risk reduction criterion. In these tables under the column "Trigger," pesticides listed as "B<sub>2</sub> Carcinogen" and/or "Endocrine Disruptor" trigger the chronic risk criterion; pesticides listed as "Acute Tox Class IA or IB" trigger the acute risk criterion.

Each of the next three tables show the original 11 active ingredients triggering the acute and chronic risk reduction goals in the third column. These are the only chemicals that "count" in assessing attainment of the 1997 risk reduction goals. The tables also show, in the fourth column, the additional active ingredients that will, in some fashion, be incorporated in monitoring attainment of future risk reduction goals.

Table 4 is entitled "Active Ingredients Triggering WWF-WPVGA Risk Reduction Goals: Percent Acres Treated in 1995, 1997 and 1998." It shows that, with the exception of metiram and piperonyl butoxide, there were no

major changes since crop year 1995, our baseline year, in the use of the nine pesticides triggering a risk criterion in 1998 for the first time.

Table 5 presents pounds applied data for 1995, 1997, and 1998 for the 18 pesticides applied in 1998 that fall under the two risk reduction goals. There are a total of 20 active ingredients used since 1995 that are subject to the risk reduction goals, but two were not applied in 1998 (oxamyl and carbofuran).

Table 6 focuses on toxicity units over the same time period. As is clear from earlier tables, the industry still achieved substantial reduction in the toxicity units associated with the acute toxicity goal, while there was slippage relative to the chronic toxicity goal because of increased use of high-risk fungicides.

Finally, in Table 7 we summarize the toxicity units in 1995, 1997 and 1998 for the original set of 11 pesticides triggering the acute and chronic risk criterion. All toxicity unit calculations in the table use the updated active ingredient toxicity factor values, so changes in toxicity units reflect actual changes in use.

The Wisconsin potato industry is well-posed to meet the 50 percent acute toxicity reduction goal in crop year 1999 given progress already made and the registration of several promising, reduced risk insecticides. More substantial changes will be needed in fungicide use and disease management to meet the chronic risk reduction goal if blight disease pressure remains unchanged.

**Table 4. Active Ingredients Triggering WWF-WPVGA Risk Reduction Goals: Percent Acres Treated 1995, 1997 and 1998**

		1995-1997 Active Ingredients Subject to Reduction Goal	1998 Active Ingredients Subject to Reduction Goal	1995 Percent acres treated	1997 Percent acres treated	1998 Percent acres treated
<b>Trigger</b>	<b>Pesticide Type</b>					
B2 Carcinogen	Fungicide	chlorothalonil	chlorothalonil	88	97	90
B2 Carcinogen	Fungicide	triphenyltin hydroxide	triphenyltin hydroxide	46	47	47
B2; Endocrine Disruptor	Fungicide	mancozeb	mancozeb	86	67	83
B2; Endocrine Disruptor	Fungicide	maneb	maneb	14	21	4
Endocrine Disruptor	Fungicide		metiram			13
<b>Trigger</b>	<b>Pesticide Type</b>					
Endocrine Disruptor	Herbicide		linuron	9	7	17
Endocrine Disruptor	Herbicide	metribuzin	metribuzin	89	93	72
Endocrine Disruptor	Herbicide		pendimethalin	36	29	27
<b>Trigger</b>	<b>Pesticide Type</b>					
Acute Tox Class 1A	Insecticide		disulfoton			0
Acute Tox Class 1A	Insecticide		ethoprophos			1
Acute Tox Class 1B	Insecticide	azinphos-methyl	azinphos-methyl	26		1
Acute Tox Class 1B	Insecticide	carbofuran		16		
Acute Tox Class 1B	Insecticide	methamidophos	methamidophos	65	22	24
Acute Tox Class 1B	Insecticide	oxamyl		8		
Endocrine Disruptor	Insecticide		dimethoate	28	59	48
Endocrine Disruptor	Insecticide	endosulfan	endosulfan	66	13	32
Endocrine Disruptor	Insecticide		esfenvalerate	60	59	81
Endocrine Disruptor	Insecticide	permethrin	permethrin	22		13
Endocrine Disruptor	Insecticide		piperonyl butoxide	17	23	40
Endocrine Disruptor	Insecticide		pyrethrins	10		8

**Table 5. Active Ingredients Triggering WWF-WPVGA Risk Reduction Goals: Toxicity Units 1995, 1997 and 1998**

		1995-1997 Active Ingredients Subject to Reduction Goal	1998 Active Ingredients Subject to Reduction Goal	1995 Toxicity Units	1997 Toxicity Units	1998 Toxicity Units
<b>Trigger</b>	<b>Pesticide Type</b>					
B2 Carcinogen	Fungicide	chlorothalonil	chlorothalonil	33,357,007	48,318,606	36,114,720
B2 Carcinogen	Fungicide	triphenyltin hydroxide	triphenyltin hydroxide	4,615,905	3,077,270	4,046,823
B2; Endocrine Disruptor	Fungicide	mancozeb	mancozeb	81,355,826	56,672,626	86,684,698
B2; Endocrine Disruptor	Fungicide	maneb	maneb	12,338,435	10,065,566	1,306,937
Endocrine Disruptor	Fungicide		metiram	0	0	16,722,741
<b>Total Toxicity Units</b>				<b>131,667,173</b>	<b>118,134,068</b>	<b>144,875,919</b>
<b>Trigger</b>	<b>Pesticide Type</b>					
Endocrine Disruptor	Herbicide		linuron	541,064	231,884	1,098,658
Endocrine Disruptor	Herbicide	metribuzin	metribuzin	4,968,192	4,331,244	4,569,246
Endocrine Disruptor	Herbicide		pendimethalin	3,161,784	2,107,856	2,150,776
<b>Total Toxicity Units</b>				<b>8,671,040</b>	<b>6,670,984</b>	<b>7,818,680</b>
<b>Trigger</b>	<b>Pesticide Type</b>					
Acute Tox Class 1A	Insecticide		disulfoton	0	0	59,476
Acute Tox Class 1A	Insecticide		ethoprophos	0	0	966,355
Acute Tox Class 1B	Insecticide	azinphos-methyl	azinphos-methyl	7,986,775	0	41,805
Acute Tox Class 1B	Insecticide	carbofuran	carbofuran	4,985,500	0	0
Acute Tox Class 1B	Insecticide	methamidophos	methamidophos	16,464,923	4,056,575	4,572,987
Acute Tox Class 1B	Insecticide	oxamyl	oxamyl	1,410,000	0	0
Endocrine Disruptor	Insecticide		dimethoate	3,908,791	10,660,340	9,016,064
Endocrine Disruptor	Insecticide	endosulfan	endosulfan	16,257,604	2,709,601	6,835,579
Endocrine Disruptor	Insecticide		esfenvalerate	1,445,800	963,867	2,460,294
Endocrine Disruptor	Insecticide	permethrin	permethrin	1,151,078	0	669,072
Endocrine Disruptor	Insecticide		piperonyl butoxide	177,444	414,035	1,117,774
Endocrine Disruptor	Insecticide		pyrethrins	3,278	0	340,303
<b>Total Toxicity Units</b>				<b>53,791,193</b>	<b>18,804,418</b>	<b>26,079,709</b>
<b>Total Toxicity Units All AI Triggers</b>				<b>194,129,406</b>	<b>143,609,470</b>	<b>178,774,308</b>

**Table 6. Active Ingredients Triggering WWF-WPVGA Risk Reduction Goals: Pounds Applied 1995, 1997 and 1998**

		1995-1997 Active Ingredients Subject to Reduction Goal	1998 Active Ingredients Subject to Reduction Goal	1995 Pounds Applied	1997 Pounds Applied	1998 Pounds Applied
<b>Trigger</b>	<b>Pesticide Type</b>					
B2 Carcinogen	Fungicide	chlorothalonil	chlorothalonil	408,000	591,000	441,730
B2 Carcinogen	Fungicide	triphenyltin hydroxide	triphenyltin hydroxide	12,000	8,000	10,521
B2; Endocrine Disruptor	Fungicide	mancozeb	mancozeb	412,000	287,000	438,986
B2; Endocrine Disruptor	Fungicide	maneb	maneb	76,000	62,000	8,050
Endocrine Disruptor	Fungicide		metiram	0	0	66,688
			<b>Total Pounds Applied</b>	<b>908,000</b>	<b>948,000</b>	<b>965,975</b>
<b>Trigger</b>	<b>Pesticide Type</b>					
Endocrine Disruptor	Herbicide		linuron	7,000	3,000	14,214
Endocrine Disruptor	Herbicide	metribuzin	metribuzin	39,000	34,000	35,868
Endocrine Disruptor	Herbicide		pendimethalin	24,000	16,000	16,326
			<b>Total Pounds Applied</b>	<b>70,000</b>	<b>53,000</b>	<b>66,408</b>
<b>Trigger</b>	<b>Pesticide Type</b>					
Acute Tox Class 1A	Insecticide		disulfoton	0	0	110
Acute Tox Class 1A	Insecticide		ethoprophos	0	0	2,850
Acute Tox Class 1B	Insecticide	azinphos-methyl	azinphos-methyl	2,600	0	190
Acute Tox Class 1B	Insecticide	carbofuran	carbofuran	13,000	0	0
Acute Tox Class 1B	Insecticide	methamidophos	methamidophos	69,000	17,000	19,164
Acute Tox Class 1B	Insecticide	oxamyl	oxamyl	5,000	0	0
Endocrine Disruptor	Insecticide		dimethoate	11,000	30,000	25,373
Endocrine Disruptor	Insecticide	endosulfan	endosulfan	60,000	10,000	25,227
Endocrine Disruptor	Insecticide		esfenvalerate	3,000	2,000	5,105
Endocrine Disruptor	Insecticide	permethrin	permethrin	4,000	0	2,325
Endocrine Disruptor	Insecticide		piperyonyl butoxide	3,000	7,000	18,898
Endocrine Disruptor	Insecticide		pyrethrins	16	0	1,661
			<b>Total Pounds Applied</b>	<b>170,616</b>	<b>66,000</b>	<b>100,903</b>
<b>Total Pounds Applied All AI Triggers</b>				<b>1,148,616</b>	<b>1,067,000</b>	<b>1,133,286</b>

<b>Table 7. WWF-WPVG Pesticide Risk Reduction Goals and Accomplishments: 1995 to 1997 and 1995 to 1998 for 11 Targeted Pesticides</b>						
Wisconsin Acres 1995 = 83,000 Wisconsin Acres 1997 and 1998 = 78,000	Pounds Applied 1995	1995 Toxicity Units Subject to Reduction Goals	Pounds Applied 1997	1997 Toxicity Units	Pounds Applied 1998	1998 Toxicity Units
<b>Acute Goal</b>						
Methamidophos	69,000	16,464,923	17,000	4,056,575	19,164	4,572,987
Azinphos-methyl	26,000	7,986,775	-	-	190	58,372
Carbofuran	13,000	4,985,500	-	-		
Oxamyl	5,000	1,410,000	-	-		
<b>Total: 4 Acute Pesticides</b>	<b>113,000</b>	<b>30,847,198</b>	<b>17,000</b>	<b>4,056,575</b>	<b>19,354</b>	<b>4,631,359</b>
<b>Per Planted Acre</b>	<b>1.36</b>	<b>372</b>	<b>0.22</b>	<b>48.9</b>	<b>0.2</b>	<b>55.8</b>
<b>Reduction Needed to Meet 25% Industry-wide Goal</b>		<b>7,711,800</b>				
Actual Reduction: 1995 to 1997				<b>26,790,623</b>		
Multiple of Needed Reduction				3.5		
Actual Reduction: 1995 to 1998						<b>26,215,839</b>
<b>Chronic Goal</b>						
Mancozeb	412,000	81,355,826	287,000	56,672,626	438,986	86,684,698
Chlorothalonil	408,000	33,357,007	591,000	48,318,606	441,730	36,114,720
Endosulfan	60,000	16,257,604	10,000	2,709,601	25,227	6,835,579
Maneb	76,000	12,338,435	62,000	10,065,566	8,050	1,306,937
Triphenyltin hydroxide	12,000	4,615,905	8,000	3,077,270	10,521	4,046,823
Metribuzin	39,000	4,968,192	34,000	4,331,244	35,868	4,569,246
Permethrin	4,000	1,151,078	-	-	2,325	669,072
<b>Total: 7 Chronic Pesticides</b>	<b>1,011,000</b>	<b>154,044,047</b>	<b>992,000</b>	<b>125,174,913</b>	<b>962,707</b>	<b>140,227,075</b>
<b>Per Planted Acre</b>	<b>12.2</b>	<b>1,856</b>	<b>12.7</b>	<b>1,605</b>	<b>12.3</b>	<b>1,798</b>
<b>Reduction Needed to Meet 15% 1995 to 1997 Industry-wide Goal</b>		<b>23,106,607</b>				
Actual Reduction: 1995 to 1997				<b>28,869,134</b>		
Multiple of Needed Reduction				1.2		
Actual Reduction: 1995 to 1998						<b>13,816,972</b>
<b>11 Targeted Pesticides: Totals</b>						
	1,124,000	184,891,245	1,009,000	129,231,488	982,061	144,858,434
Change 1995-1997			115,000	55,659,757	141,939	40,032,811
Percent Change 1995-1997			-10%	-30%		
Change 1995-1998					141,939	40,032,811
Percent Change 1995-1998					-13%	-22%

It is clear from Table 7 that the Wisconsin potato industry is well-posed to meet their 50 percent acute toxicity reduction goal in crop year 1999, but will need substantial changes in fungicide use to meet the chronic toxicity unit reduction goal of 30 percent. As stated above, growers will meet the goal if they replace about one-half EBDC fungicide applications with one of the three new reduced risk fungicides, azoxystrobin, dimethomorph, and cymoxanil. Without these three new products, the industry

would have few options to achieve the goal, unless late and early blight disease pressure markedly subsides from levels prevalent since the 1994. While a possibility, it is perhaps equally likely that another new strain of blight disease will emerge. This will place additional pressure on currently registered products and the skill of farmers, who will have to become even more aggressive in treating disease outbreaks and in efforts to isolate them where they first arise.

## **NEXT STEPS IN REFINING MEASURES OF PESTICIDE USE, RELIANCE, AND RISKS**

Progress in the field 1998 and this year's measurement activities have answered some questions and raised new ones. It has also heightened interest in developing better ways to incorporate

diversity across time and space in pest pressure and pest management systems into the measurement tools used to monitor progress toward biointensive IPM in Wisconsin.

### **Spatial and Temporal Diversity Offers New Management Options**

The Wisconsin IPM team and a number of cooperating growers have made a significant investment in the application of GIS-based methods to intensively monitor and map the status of crops, pest pressure and movement, the presence of beneficials, and the impacts of management interventions at weekly intervals through the growing season.

The intensive sampling data has already led to several insights regarding how and why pests move through fields, become a problem in some areas and years, but not others, and how management practices impact populations. These insights are beginning to provide clues on how neighboring growers can "join forces" in carrying out area-wide IPM systems that achieve an even higher level of overall pest population suppression, and also slow, if not reverse pest spread.

As better methods are developed to measure pest pressure, we will work to

draw upon the concepts and data in developing new "pest pressure" variables to incorporate in the measurement of progress along the IPM continuum.

Pest pressure parameters are also needed in order to implement the "emergency pest management" clause of the MOU. This clause could periodically be critical, especially after the 2001 when the use reduction goals call for 100 percent reductions, i.e., no use, of all pesticides triggering the acute or chronic risk criterion. Given that pesticides accounting for over 85 percent of total industry-wide use (measured by pounds applied) fall under these criterion, it is likely that circumstances will arise after crop year 2002 when growers will need to apply some of today's higher-risk materials. In order to deal with such circumstances, progress is needed in the development of tools that can be used to objectively measure and track changes in pest pressure.

### **Refinements Needed in Estimating Toxicity Factor Values**

Several additional steps are needed to develop more accurate measures of pesticide toxicity and use. In calculating human chronic risks, much new data will become available as the EPA implements the FQPA. Within the next five years, many pesticides are likely to be subjected to detailed screens to assess capacity to

impact the endocrine system. New methods will be needed to incorporate new toxicological information into the chronic mammalian toxicity factor.

A critical need exists to establish a number of physical and chemical properties impacting the likelihood of human exposure occurring from pesticide

application. In particular, the advisory committee has urged the project team to work into the multiattribute equation estimates of a pesticide's likelihood to leach to groundwater – a major concern in the Central Sands of Wisconsin where groundwater is often within a dozen feet of the surface. An initial attempt to take leaching potential into account – use of the NRCS “Sci-Grow” model – has been abandoned because of a lack of confidence in the values it produced.

Fortunately, several academic teams are working on improved hydrogeological models. These should, within a few years, produce a much-refined set of leaching factors. More advanced models will even produce leaching factor values associated with certain soil types.

In the ecotoxicity component of the equation, much effort will be required to bring the aquatic and fish toxicity parameters up to the standards now set by the Mineau acute avian toxicity data. While work progresses to refine the fish and small aquatic organism data, Dr. Mineau is progressing to complete a chronic avian toxicity index, which will be incorporated into the ecotoxicity formula when a consistent dataset is available.

Substantial work will also be needed to improve the dataset supporting BioIPM values. The bee toxicity database is now of high quality and nearly complete for pesticides use in Wisconsin potato production. But little is known about impacts on soil microbial communities and worms. Cooperative work is underway between Benbrook Consulting Services and Dr. Paul Jepson, chair of the Department of Entomology at Oregon State University. Dr. Jepson and colleagues are developing an updated and improved set of SIDEFX factor values capturing the impact of pesticides on non-target beneficial organisms. Again, this is an enormous undertaking.

We are focusing now on developing estimates for newly registered compounds, many of which are being marketed as “IPM friendly” because of their more selective mode of action. In some cases, published data support this contention, but in other cases it clearly does not. For example, the new corn insecticide fipronil is among the most damaging to a range of non-target organisms, based on recent results derived from the SIDEFX database.

New data are needed to better capture the impact of pesticides on non-target beneficial organisms, decomposers, soil microorganisms, worms and the risk of resistance emerging. These “BioIPM” data elements encompass the ways a given pesticide will either help a farmer progress along the IPM continuum or stymie efforts to incrementally back off the pesticide treadmill.

## Endnotes

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<sup>i</sup> From *Pest Management at the Crossroads*, pages 178-179, Benbrook, C., Groth, E., Hansen, M., Halloran, J., and S. Marquart, Consumers Union, 1996. See also the WWF-WPVGA Potato IPM Project Web-page, <http://www.pmac.net/wwfwpvga/home.htm> .

<sup>ii</sup> Several reasons why are set forth in "Alternative Measures of Pesticide Use," Barnard, C., Daberkow, S., Padgett, M., Smith, M.E., and N.D. Uri, *The Science of the Total Environment*, 203 (1997): 229-244.

<sup>iii</sup> See page 82, *PMAC* (Benbrook et al., 1996).

<sup>iv</sup> The index for the section "Recent IPM Measurement Activities" from the PMAC website lists a number of resource materials. "An Overview of Pesticide Impact Assessment Systems (a.k.a. 'Pesticide Risk Indicators') based on Indexing or Ranking Pesticides by Environmental Impact," an April 1997 paper by Dr. Lois Levitan, Cornell University, is particularly comprehensive and detailed, and is accessible at <http://www.pmac.net/lois.htm>.

<sup>v</sup> The design and application of multiattribute indices in evaluating pesticide risks are treated in detail in a 1995 Masters of Science thesis by D. Landy (Landy, 1995). Several toxicity ranking methods are reviewed in *Pest Management at the Crossroads* (Benbrook et al., 1996) and the extensive background paper prepared for OECD by Dr. Lois Levitan (Levitan, 1997).

<sup>vi</sup> For more details on the derivation of Mam Tox Score and other components of the WWF-WPVGA multiattribute risk index, see the technical paper "A Methodology for Adjusting Pesticide Use Data For the Toxicity of Active Ingredients," (Benbrook, 1998; accessible at <http://www.pmac.net/potatipm.htm>).

# ***Appendix 1***

## ***WWF-WVPGA Toxicity Units***

**Appendix 1 Table 1: Changes in Acute and Chronic Mammalian Toxicity Factor Values**

	1997 Inverse LD50	1998 Inverse LD50	1997 Chronic Toxicity	1998 Chronic Toxicity
<b>New for 1998</b>				
2,4-D		1.33		30.0
alachlor		0.54		30.0
azoxystrobin		0.10		0.6
basic copper sulfate		0.20		0.3
dimethomorph		0.13		10.0
disulfoton		192.31		200.0
malathion		0.24		7.5
petroleum oils		0.10		0.3
phosmet		2.17		33.3
azinphos-methyl	27.69	31.25	59.1	66.7
chlorothalonil	0.09	0.10	7.8	8.8
copper ammonium	0.67	1.67	0.3	0.3
copper hydroxide	0.44	0.50	0.3	0.3
copper resinate	0.09	0.10	0.3	0.3
copper sulfate	1.46	1.67	0.3	0.3
cymoxanil	0.46	0.52	5.5	6.3
dimethoate	2.93	3.33	175.8	200.0
diquat	1.9	2.16	39.8	45.5
endosulfan	5.53	6.25	44.2	50.0
endothal	8.62	9.80	4.4	5.0
esfenvalerate	6.55	7.46	4.4	5.0
ethoprophos	19.35	19.23	200.0	200.0
fonofos	55.06	62.50	44.0	50.0
glyphosate	0.1	0.12	0.0	0.1
imidacloprid	0.97	1.11	0.2	1.8
linuron	0.11	0.13	11.2	12.5
maleic hydrazide	0.11	0.10	0.5	0.4
mancozeb	0.09	0.10	114.7	130.0
maneb	0.09	0.10	80.1	90.0
metalaxyl	0.75	0.75	1.4	1.4
metam sodium	1.54	1.75	95.5	109.0
methamidophos	14.6	16.67	87.6	100.0
metiram	0.09	0.10	200.0	200.0
metolachlor	0.17	0.18	0.9	1.0
metribuzin	0.26	0.23	26.8	23.1
paraquat dichloride	2.92	3.33	19.5	22.2
pendimethalin	0.42	0.48	0.7	2.3
permethrin	0.88	1.00	9.3	10.6
phorate	200	200.00	176.3	200.0
piperonyl butoxide	0.09	0.10	5.0	17.1
propamocarb hydrochloride	0.09	0.10	0.9	1.0
pyrethrins	0.88	0.33	1.4	4.7
rimsulfuron	0.11	0.10	7.1	6.3
sethoxydim	0.14	0.16	1.0	1.1
sulfur	0.15	0.17	0.1	0.3
sulfuric acid	0.44	0.50	0.3	0.3
triphenyltin hydroxide	2.81	3.21	200.0	200.0

**Appendix 1 Table 2: Changes in Ecotoxicity Factor Values**

	1995-1997 Daphnia	1998 Daphnia	1995-1997 Fish	1998 Fish	1995-1997 Avian	1998 Avian	1995-1997 Combined Index	1998 Combined Index
<b>New for 1998</b>								
2,4-D		0.01		0.03		0.23		2.63
alachlor		0.00		0.03		0.09		1.17
azoxystrobin		1.00		3.00		0.13		41.29
basic copper sulfate		0.03		0.15		0.64		8.09
dimethomorph		0.10		1.00		0.14		12.44
disulfoton		0.36		0.00		35.99		36.35
malathion		0.10		0.10		0.22		0.42
petroleum oils								
phosmet		0.00		0.00		24.19		24.20
azinphos-methyl	0.01	0.01	16.70	16.69	12.15	13.13	28.80	29.84
chlorothalonil	0.36	0.36	2.27	2.27	0.00	0.16	26.30	27.82
copper ammonium	0.03	0.03	0.01	0.01	0.10	0.14	1.30	1.77
copper hydroxide	0.03	0.03	0.09	0.09	0.47	0.14	5.80	2.54
copper resinate	0.03	0.03	0.01	0.01	0.47	0.14	5.00	1.80
copper sulfate	0.03	0.03	0.15	0.09	0.47	0.13	6.40	2.50
cymoxanil	0.00	0.00	0.01	0.01	0.47	0.13	4.80	1.41
dimethoate	10.00	10.00	0.03	0.03	5.04	5.19	15.10	15.22
diquat	0.00	0.00	0.00	0.00	0.12	1.68	1.20	16.89
endosulfan	0.15	0.15	115.08	115.08	19.54	3.15	134.80	118.38
endothal	0.00	0.00	0.00	0.00	0.15	1.03	1.50	10.31
esfenvalerate	166.67	166.67	500.00	500.00	1.84	0.23	200.00	200.00
ethoprophos	0.37	0.37	0.11	0.11	11.72	12.45	12.20	12.95
fonofos	12.50	12.50	5.82	5.81	7.35	10.48	25.70	28.80
glyphosate	0.00	0.00	0.00	0.00	0.14	0.13	1.40	1.31
imidacloprid	0.00	0.00	0.00	0.00	1.88	3.56	1.90	3.56
linuron	0.13	0.13	0.03	0.03	0.21	0.46	3.60	6.16
maleic hydrazide	0.00	0.00	0.00	0.00	1.81	0.14	18.10	1.40
mancozeb	0.03	0.03	0.16	0.16	0.10	0.04	2.80	2.24

## Appendix 1 Table 2: Changes in Ecotoxicity Factor Values

	1995-1997 Daphnia	1998 Daphnia	1995-1997 Fish	1998 Fish	1995-1997 Avian	1998 Avian	1995-1997 Combined Index	1998 Combined Index
maneb	0.01	0.01	0.71	0.71	0.06	0.09	7.70	8.02
metalaxyl	0.00	0.00	0.00	0.00	0.07	0.34	0.70	3.39
metam sodium	0.01	0.01	0.25	0.25	0.08	0.52	3.40	7.74
methamidophos	0.73	0.74	0.01	0.00	10.91	17.62	11.60	18.36
metiram	0.00	0.00	0.00	0.00	0.10	0.12	1.10	1.25
metolachlor	0.00	0.00	0.03	0.03	0.08	0.12	1.10	1.50
metribuzin	0.01	0.00	0.00	0.00	0.29	0.71	3.00	7.22
paraquat dichloride	0.02	0.02	0.00	0.01	2.08	0.34	12.90	3.71
pendimethalin	0.09	0.09	0.99	0.50	0.21	0.50	21.10	10.87
permethrin	13.30	13.30	28.16	28.16	1.64	0.01	43.10	41.47
phorate	0.68	0.68	86.46	86.46	75.00	93.43	162.10	180.56
piperonyl butoxide	0.02	0.02	0.04	0.04	1.60	0.11	1.70	0.18
propamocarb hydrochloride	0.00	0.00	0.00	0.00	0.16	0.09	1.60	0.94
pyrethrins	2.16	2.16	8.86	8.86	0.90	0.03	11.90	11.05
rimsulfuron	0.00	0.00	0.00	0.00	0.28	0.19	2.80	1.87
sethoxydim	0.00	0.00	0.00	0.00	0.15	0.06	1.50	0.63
sulfur	0.00	0.00	0.00	0.00	0.13	0.00	1.30	0.02
sulfuric acid	0.01	0.01	0.01	0.01	0.10	0.10	1.20	1.00
triphenyltin hydroxide	2.50	2.50	5.26	5.26	0.11	4.06	78.70	118.20

**Appendix 1 Table 3: Changes in BioIPM Index Factor Values**

	1995-1997 Impact on Resistance	1998 Impact on Resistance	1995-1997 Impact on Beneficials	1998 Impact on Beneficials	1995-1997 Impact on Microorg.	1998 Impact on Microorg.	1995-1997 Impact on Bees	1998 Impact on Bees	1995-1997 BioIPM Index	1998 BioIPM Index
<b>New for 1998</b>										
2,4-D		6		17.0		80		0.10		41.24
alachlor		6		41.3		80		0.63		51.17
azoxystrobin		56		10.9		20		0.10		34.80
basic copper sulfate		5		10.9		40		1.00		22.76
dimethomorph		14		20.0		20		0.10		21.64
disulfoton		54		66.7		60		166.67		138.94
malathion		40		100.0		30		37.04		82.82
petroleum oils										
phosmet		45		33.3		30		16.39		49.89
azinphos-methyl	75	48	70.4	70.4	40	40	12.20	166.67	79.0	130.03
chlorothalonil	6	5	50.0	50.0	20	20	0.06	0.06	30.4	30.02
copper ammonium	6	5	38.0	38.0	30	30	1.00	1.00	30.0	29.60
copper hydroxide	6	5	38.3	38.3	30	30	1.00	1.00	30.1	29.72
copper resinate	6	5	38.3	38.3	30	30	1.00	1.00	30.1	29.72
copper sulfate	6	5	10.9	10.9	40	40	1.00	1.00	23.2	22.76
cymoxanil	30	14	35.0	35.0	20	20	0.40	0.40	34.2	27.76
dimethoate	15	36	71.4	71.4	40	40	76.92	83.33	81.3	92.31
diquat	6	6	40.0	40.0	20	20	10.00	0.63	30.4	26.65
endosulfan	75	63	61.4	61.4	40	40	1.61	1.41	71.2	66.30
endothal	6	6	40.0	40.0	20	20	1.00	1.00	26.8	26.80
esfenvalerate	120	192	66.7	66.7	30	30	100.00	166.67	126.7	182.13
ethoprophos	15	45	66.7	66.7	80	80	2.44	2.44	65.6	77.64
fonofos	15	23	55.6	55.6	80	80	1.47	3.03	60.8	64.44
glyphosate	6	6	41.3	41.3	80	80	0.10	0.10	51.0	50.96
imidacloprid	75	72	40.0	40.0	50	50	7.30	1,234.57	163.6	200.00
linuron	6	6	51.0	51.0	40	40	0.08	0.63	38.8	39.05
maleic hydrazide	6	6	40.0	40.0	20	20	1.00	0.63	26.5	26.65
mancozeb	6	10	78.0	78.0	20	20	0.06	0.63	41.6	43.45

**Appendix 1 Table 3: Changes in BioIPM Index Factor Values**

	1995-1997 Impact on Resistance	1998 Impact on Resistance	1995-1997 Impact on Beneficials	1998 Impact on Beneficials	1995-1997 Impact on Microorg.	1998 Impact on Microorg.	1995-1997 Impact on Bees	1998 Impact on Bees	1995-1997 BioIPM Index	1998 BioIPM Index
maneb	6	3	83.3	83.3	20	20	0.83	0.83	44.1	42.85
metalaxyl	150	150	52.5	52.5	80	80	0.10	0.10	113.0	113.04
metam sodium	6	6	60.0	60.0	80	80	0.28	0.28	58.5	58.51
methamidophos	21	48	76.9	76.9	50	50	7.30	11.63	62.1	74.62
metiram	6	7	54.8	54.8	20	20	1.00	0.63	32.7	32.97
metolachlor	9	9	17.0	17.0	50	50	0.10	0.10	30.4	30.44
metribuzin	60	60	51.0	51.0	50	50	0.17	0.63	64.5	64.65
paraquat dichloride	6	6	65.0	65.0	60	60	1.67	0.21	38.1	52.48
pendimethalin	18	120	17.0	17.0	60	60	0.20	0.20	96.4	78.88
permethrin	120	168	103.1	103.1	30	30	100.00	90.91	141.2	156.80
phorate	30	24	100.0	100.0	80	80	2.77	37.04	85.1	96.41
piperonyl butoxide	9	9	40.0	40.0	20	20	1.00	0.63	28.0	27.85
propamocarb hydrochloride	30	30	30.0	30.0	20	20	1.00	1.00	32.4	32.40
pyrethrins	120	108	100.0	100.0	30	30	1.00	76.92	100.4	125.97
rimsulfuron	120	120	51.0	51.0	70	70	0.10	0.10	53.1	96.44
sethoxydim	45	45	15.0	15.0	60	60	1.00	1.00	38.8	48.40
sulfur	6	6	87.0	87.0	20	20	0.10	0.01	45.2	45.20
sulfuric acid	6	6	20.0	20.0	20	20	1.00	1.00	18.8	18.80
triphenyltin hydroxide	6	18	70.0	70.0	20	20	0.09	0.09	38.4	43.23

## Appendix Table 4: WWF-WPVGA Project Toxicity Index: 1997 - 1998

WWF-WPVGA Multiattribute Formula:  $(0.5)*AMx + CMx + ECOx + (1.5)*BioIPMx$

	1995 - 1997 Project Index	1998 Project Index	Percent Change
<b>New for 1998</b>			
2,4-D		95.15	
alachlor		108.19	
azoxystrobin		94.10	
basic copper sulfate		42.66	
dimethomorph		54.97	
disulfoton		540.91	
malathion		132.27	
petroleum oils			
phosmet		133.45	
azinphos-methyl	220	307.18	40
chlorothalonil	80	81.76	2
copper ammonium	47	47.33	1
copper hydroxide	52	47.70	-8
copper resinate	51	46.76	-8
copper sulfate	42	37.80	-10
cymoxanil	62	49.56	-20
dimethoate	314	355.34	13
diquat	88	103.40	18
endosulfan	289	270.96	-6
endothal		60.42	
esfenvalerate	398	481.93	21
ethoprophos	320	339.03	6
fonofos	188	206.70	10
glyphosate	78	77.85	0
imidacloprid	248	305.87	23
linuron	73	77.29	6
maleic hydrazide	58	41.82	-28
mancozeb	180	197.47	10
maneb	154	162.35	5
metalaxyl	172	174.67	2
metam sodium	187	205.38	10
methamidophos	200	238.62	19
metiram	250	250.76	0
metolachlor	46	48.25	5
metribuzin	127	127.39	0
paraquat dichloride	91	106.32	17
pendimethalin	167	131.74	-21
permethrin	265	287.77	9
phorate	566	625.18	10
piperonyl butoxide	49	59.15	21
propamocarb hydrochloride	51	50.59	-1
pyrethrins	100.4	204.86	104
rimsulfuron	90	152.83	70
sethoxydim	61	74.42	22
sulfur	47	68.24	45
sulfuric acid	21		
triphenyltin hydroxide	338	384.66	14

## ***Appendix 2***

### ***Pesticide Use on Wisconsin Potato Farms: 1995, 1997 and 1998***

## Appendix 2 – 1 Wisconsin Potato Production: Pesticide Use, 1995-1998

		Acres Treated			Number of Applications			Rate Per Year			Pounds Applied		
		1995	1997	1998	1995	1997	1998	1995	1997	1998	1995	1997	1998
basic copper sulfate	F	4,150		3,976	1.9			2.9		1.7	13,000		6,878
chlorothalonil	F	73,040	75,660	70,299	5.9	7.9		5.6	7.8	6.3	408,000	591,000	441,730
copper ammonium	F			1,850						0.2			363
copper hydroxide	F	31,540	31,980	19,153	2.4	3.8		1.3	1.6	1.3	40,000	52,000	25,163
copper resinate	F	5,810	10,140	3,368	1.9	1.9		2.1	0.2	0.3	12,000	2,000	1,020
copper sulfate	F		7,020	1,259		2.7			1.1	0.5		8,000	606
cymoxanil	F		17,940	11,931		2.1			0.3	0.1		5,000	783
dimethomorph	F			2,667						0.2			551
mancozeb	F	71,380	52,260	64,663	4.7	4.4		5.8	5.5	6.8	412,000	287,000	438,986
maneb	F	11,620	16,380	3,438	5.3	3.7		6.7	3.9	2.3	76,000	62,000	8,050
metalaxyl	F	12,450		10,440	1.5			0.3		0.3	4,000		2,960
metiram	F			9,879						6.8			66,688
propamocarb hydrochloride	F	9,960		691	1.1			1.0		1.0	9,000		661
sulfur	F			1,850						1.3			2,395
triphenyltin hydroxide	F	38,180	36,660	36,825	2.9	2.2		0.3	0.2	0.3	12,000	8,000	10,521
<b>Total Fungicides</b>		<b>258,130</b>	<b>248,040</b>	<b>261,943</b>	<b>3.07</b>	<b>3.59</b>		<b>2.9</b>	<b>2.6</b>	<b>1.8</b>	<b>986,000</b>	<b>1,015,000</b>	<b>1,009,754</b>
<b>Per Acre</b>											<b>11.88</b>	<b>13.01</b>	<b>12.95</b>

		Acres Treated			Number of Applications			Rate Per Year			Pounds Applied		
		1995	1997	1998	1995	1997	1998	1995	1997	1998	1995	1997	1998
2,4-D	H			524					0.1			26	
alachlor	H			10					2.0			19	
azoxystrobin	H			19,654					0.1			2,399	
glyphosate	H	6,640	7,800	11,138	1.0	1.0	0.6	1.2	0.6	4,000	9,000	6,222	
linuron	H	7,470	5,460	13,245	1.1	1.0	1.0	0.7	1.1	7,000	3,000	14,214	
metolachlor	H	14,940	4,680	9,422	1.0	1.0	1.4	1.4	0.7	21,000	70,000	6,302	
metribuzin	H	73,870	72,540	56,147	1.1	1.0	0.5	0.5	0.6	39,000	34,000	35,868	
pendimethalin	H	29,880	22,620	20,849	1.0	1.0	0.8	0.7	0.8	24,000	16,000	16,321	
rimsulfuron	H			26,587					0.0			736	
sethoxydim	H	8,300		5,235	1.2		0.2		0.2	2,000		982	
<b>Total Herbicides</b>		<b>141,100</b>	<b>113,100</b>	<b>216,424</b>	<b>1.07</b>	<b>1.00</b>	<b>0.8</b>	<b>0.9</b>	<b>0.6</b>	<b>97,000</b>	<b>132,000</b>	<b>113,401</b>	
<b>Per Acre</b>										<b>1.17</b>	<b>1.69</b>	<b>1.45</b>	
azinphos-methyl	I	21,580		594	2.1		1.2		0.3	26,000		190	
carbofuran	I	13,280			1.0		0.9			13,000			
diazinon	I			1,752					0.3			491	
dimethoate	I	23,240	46,020	37,105	1.3	1.6	0.5	0.6	0.7	11,000	30,000	25,373	
disulfoton	I			105					1.0			110	
endosulfan	I	54,780	10,140	24,959	1.5	1.3	1.1	1.1	1.0	60,000	10,000	25,227	
esfenvalerate	I	49,800	46,020	63,070	1.7	1.2	0.1	0.1	0.1	3,000	2,000	5,105	
ethoprophos	I			950					3.0			2,850	
fonofos	I			19					2.0			39	
imidacloprid	I		36,660	33,972		1.1		0.2	0.2		8,000	7,322	
methamidophos	I	53,950	17,160	18,975	1.4	1.0	1.3	1.0	1.0	69,000	17,000	19,164	
oxamyl	I	6,640			1.1		0.8			5,000			
permethrin	I	18,260		10,205	1.4		0.2		0.2	4,000		2,325	
phorate	I			78					2.3			175	

		Acres Treated			Number of Applications			Rate Per Year			Pounds Applied		
		1995	1997	1998	1995	1997	1998	1995	1997	1998	1995	1997	1998
phosmet	I			5,498					0.6			3,489	
piperynyl butoxide	I	14,110	17,940	31,050	1.0	1.2	0.2	0.4	0.6	3,000	7,000	18,898	
pyrethrins	I	8,300		6,457	1.0		0.0		0.3	166		1,661	
<b>Total Insecticides</b>		<b>263,940</b>	<b>173,940</b>	<b>234,788</b>	<b>1.35</b>	<b>1.23</b>	<b>0.6</b>	<b>0.6</b>	<b>0.9</b>	<b>194,166</b>	<b>74,000</b>	<b>112,419</b>	
<b>Per Acre</b>										<b>2.34</b>	<b>0.95</b>	<b>1.44</b>	
diquat	O			68,070					0.4			28,541	
diquat dibromide	O	66,400	56,160		1.4	1.5	0.4	0.5		28,000	26,000		
endothal	O	9,130		950	1.1		0.8		0.2	7,000		185	
maleic hydrazide	O	6,640		1,281	1.0		1.9		2.3	13,000		2,920	
metam sodium	O	6,640		14,335	1.0		152.0		122.6	970,000		1,756,885	
paraquat dichloride	O	5,810		4,248	1.2		0.5		0.9	3,000		3,983	
petroleum oils	O			827					0.2			141	
sulfuric acid	O	10,790	14,040	3,528	1.1	1.4	150.3	195.3	142.0	1,632,000	2,770,000	500,960	
<b>Total Other Pesticides</b>		<b>105,410</b>	<b>70,200</b>	<b>19,971</b>	<b>1.13</b>	<b>1.45</b>	<b>51.0</b>	<b>97.9</b>	<b>66.8</b>	<b>2,653,000</b>	<b>2,796,000</b>	<b>2,260,906</b>	
<b>Per Acre</b>										<b>31.96</b>	<b>35.85</b>	<b>28.98</b>	
<b>Total All Pesticides</b>		<b>768,580</b>	<b>605,28</b>	<b>733,126</b>	<b>1.75</b>	<b>2.10</b>				<b>3,930,166</b>	<b>4,017,000</b>	<b>3,496,479</b>	
<b>Per Acre</b>										<b>47.35</b>	<b>51.50</b>	<b>44.82</b>	