Distribution of Wisconsin Potato Growers Along the Integrated Pest Management Continuum: The 1998 Baseline

INTRODUCTION

A key objective of the WWF-WPVGA potato Integrated Pest Management (IPM) project in Wisconsin is demonstrating the linkages between progress along the IPM continuum and lessened reliance on high-risk pesticides. The IPM continuum ranges from a "no" IPM zone where growers rely predominantly on chemical-based interventions to "high," or biointensive IPM. The four zones include no, low, medium, and high levels of IPM, or zones along the continuum. The IPM continuum is depicted graphically in Figure 1.

At the "no" and "low" end of the continuum, pesticides are applied routinely, and bear most of the burden in managing pests. As more preventive practices are introduced into an IPM system, reliance on pesticides typically falls as growers shift into the "medium" and biointensive zones along the continuum. In addition, growers tend to sharply reduce applications of disruptive, broad-spectrum pesticides that can trigger secondary pest problems and decrease populations of beneficial organisms. In general, there is a premium on timely, accurate field information and greater reliance on pest management skills among growers that reach the "medium" and "high" zones along the continuum.

Figure 1. The IPM Continumm

Incremental progress along the IPM continuum is essential in reducing reliance and use of high-risk pesticides.

No IPM	**← Transitional Systems →**		**High or Biointensive IPM**
	Low	**Medium**	
→ → → Shifting Reliance From Treatment to Prevention → → →			
Chemical Based →→ → → →→ →→ → → **Biologically Based**			

WWF-WPVGA project goals include incremental progress along the IPM continuum for the industry as a whole. Such progress requires increasing the percentage of acreage managed in the medium and high, or biointensive zones along the IPM continuum and a shift of acres out of the no and low zones.

This paper describes the establishment of the crop year 1998 Wisconsin potato industry IPM baseline from which progress will be monitored in future years. The location of a given surveyed potato field along the continuum is established by the value of the "IPM System Ratio" specific to that field. The numerator of this ratio is field-specific total "Preventive Practice Points" (PPPs) per acre, based on the actual IPM system practices reported by the grower. The methodology used to establish the points associated with each practice, along with the weights assigned to different sets of practices, is described in detail in the draft paper "Measuring Grower's Use of Practices in the Adoption of Biointensive Integrated Pest Management," by Dr. Pete Nowak and Mr. Michael Peterson.

The denominator used in calculating the IPM system ratio values is a measure of the intensity of pesticide use, often referred to as "toxicity adjusted" pesticide use. It is established by multiplying the pounds of each pesticide reported as applied on the surveyed field by the active ingredient's "BioIPM Impact" index. The derivation of this index is described in the next section.

Survey of Growers

In crop year 1997, a survey was carried out of IPM practices and pesticide use at the field level. Based on in-depth analysis of the results and discussions with growers and consultants actively implementing IPM, the survey instrument was substantially improved and expanded for the 1998 growing season.

In 1998 a total of 90 complete responses was received and has been tabulated. About another 40 growers responded to portions of the survey, but incompletely, so these responses have not been used in establishing the baseline.

The 90 farms range in size from a total of over 4,000 acres in potatoes to just 1 acre. Sampled field sizes ranged from 1 acre to 200 acres, with most sampled fields falling in the range of 50 to 150 acres in potatoes.

The Wisconsin potato industry includes fresh market, processing and seed producers. Among the 90 surveyed fields, growers reported that 48 produced processing potatoes, 35 fresh market potatoes, and 7 were used to grow seed potatoes. In subsequent analyses, we assumed that all potato acres on a farm were grown for the same market as the surveyed fields.

A. Developing the "BioIPM Impact" Index

During the May 1999 project advisory committee meeting in Madison, Wisconsin, it was agreed that for purposes of measuring IPM adoption along the continuum, we needed a different formula for calculating toxicity adjusted pesticide use than the formula used when monitoring attainment of industry-wide risk reduction goals. The committee favored developing a "BioIPM Impact" index that reflects more closely the impacts, from the perspective of growers, of different pesticides on the viability of biointensive IPM.

The theoretical foundation of the IPM continuum is rooted in the ecological dynamics governing the relative population levels of pests and beneficials within farm fields. The IPM System Ratio strives to measure progress away from treatment-oriented interventions in managing pests and toward systematic reliance and skillful deployment of multitactic prevention-based IPM systems. For a full discussion of the IPM continuum and this notion of shifting reliance see *Pest Management at the Crossroads* (Benbrook et al., 1996).

Accordingly, in calculating "BioIPM Impact" toxicity units, we have increased the weights placed on those properties of pesticides that most directly determine their impact on the viability of biointensive IPM systems. We have lessened the weights placed on measures of

mammalian toxicity and risk – factors that feature more prominently in the overall WWF-WPVGA index used for monitoring the overall impacts of pesticides used the Wisconsin's potato growing areas.

BioIPM Impact Index values used in establishing the IPM continuum in 1998 should be considered preliminary since much work is needed to both refine and expand the underlying concepts included in the index, and in gathering better data to quantify index components. While values will no doubt change, we anticipate that the relative ranking produced by our preliminary values will remain largely intact.

BioIPM Impact Formula

In developing the formula used in calculating BioIPM Impact values, we asked ourselves "What factors should farmers and pest management professionals working to move along the IPM continuum take into account when choosing among alternative control tactics and alternative pesticides?" We then sought to incorporate those factors into the formula. Our choice of factors was constrained to those parameters for which we have data on all pesticides applied in Wisconsin potato production in 1998, a constraint we hope to relax in future years. In addition, we did not include costs per acre treatment; a critical factor to be included in future analyses.

The six factors used in calculating preliminary BioIPM Impact index values are listed below. The weights assigned to each factor are in the parentheses –

- Acute toxicity to mammals measured by LD-50s (weight equal to 0.25).
- Impact on Microorganisms (0.5).
- Avian toxicity (1.5).
- Bee toxicity (0.5)
- Impact on resistance (1.0)
- Impacts on beneficials (2.0)

In all cases, the above factors are scaled such that values rise with increasing toxicity, and the range of values is roughly comparable. For details on the derivation of the above values and data sources, see "Measurement System Changes and Progress Toward Meeting WWF-WPVGA Pesticide Risk Reduction Goals: A Crop Year 1998 Status Report," by Dr. Charles Benbrook (accessible at http://www.pmac.net/potatipm.htm.)

Table 1 presents the values for the six component indices used in calculating BioIPM Impact index values, along with the final values, arranged by type of pesticide. Table 2 presents the same data alphabetically to simplify location of a specific active ingredient. The values in the columns already include the weights noted above – which explains why the values under "Acute Toxicity" differ in this table compared to others reporting full "Inverse LD-50" values by active ingredient. Note also that in the case of four active ingredients in the column "Impacts on Beneficials," we have set maximum values at 200 to avoid a single parameter skewing the final value for a given active ingredient.

Table 1. BIOIPM Impact Factor Values

Formula: (0.25)*Acute toxicity + (0.5)*Impact on Microorganisms + (1.5)*Avian Toxicity + (0.5) Bee Toxicity + (1.0)*Impact on Resistance + (2.0)*Impact on Beneficials

Active Ingredient	Acute Toxicity	Micro-organism Impact	Avian Toxicity	Bee Toxicity	Impact on Resistance	Impacts on Beneficials	BIOIPM Impact Factor
HERBICIDES							
2,4-D	0.33	40	0.34	0.05	6	34.0	80.72
alachlor	0.13	40	0.14	0.31	6	82.6	129.18
diquat	0.54	10	2.53	0.31	6	80.0	99.38
endothal	2.45	10	1.54	0.50	6	80.0	100.49
glyphosate	0.03	40	0.19	0.05	6	82.6	128.87
linuron	0.03	20	0.69	0.31	6	102.0	129.04
metolachlor	0.04	25	0.19	0.05	9	34.0	68.28
metribuzin	0.06	25	1.07	0.31	60	102.0	188.44
paraquat dichloride	0.83	30	0.51	0.10	6	130.0	167.45
pendimethalin	0.12	30	0.75	0.10	120	34.0	184.97
rimsulfuron	0.03	35	0.28	0.05	120	102.0	257.35
sethoxydim	0.04	30	0.09	0.50	45	30.0	105.63
INSECTICIDES							
azinphos-methyl	7.81	20	19.70	83.33	48	140.8	319.69
dimethoate	0.83	20	7.78	41.67	36	142.9	249.14
disulfoton	48.08	30	53.99	83.34	54	133.3	402.74
endosulfan	1.56	20	4.72	0.70	63	122.7	212.69
esfenvalerate	1.87	15	0.34	83.33	192	133.3	425.88
ethoprophos	4.81	40	18.68	1.22	45	133.3	243.04
fonofos	15.63	40	15.72	1.52	23	111.1	206.48
imidacloprid	0.28	25	5.34	25.00	72	80.0	207.62
malathion	0.06	15	0.32	18.52	40	200.0	273.90
methamidophos	4.17	25	26.43	5.81	48	153.8	263.25
permethrin	0.25	15	0.01	45.45	168	206.2	434.90
phorate	50.00	40	140.14	18.52	24	200.0	472.66
phosmet	0.54	15	36.29	8.20	45	66.7	171.69
piperonyl butoxide	0.03	10	0.17	0.31	9	80.0	99.51
pyrethrins	0.08	15	0.05	38.46	108	200.0	361.59
FUNGICIDES							
azoxystrobin	0.03	10	0.19	0.05	56	21.8	88.07
basic copper sulfate	0.05	20	0.96	0.50	5	21.8	48.31
chlorothalonil	0.03	10	0.23	0.03	5	100.0	115.29
copper ammonium	0.42	15	0.21	0.50	5	76.0	97.13
copper hydroxide	0.13	15	0.21	0.50	5	76.6	97.43
copper resinate	0.03	15	0.22	0.50	5	76.6	97.34
copper sulfate	0.42	20	0.19	0.50	5	21.8	47.91
cymoxanil	0.13	10	0.19	0.20	14	70.0	94.52
dimethomorph	0.03	10	0.22	0.05	14	40.0	64.30
mancozeb	0.03	10	0.06	0.31	10	156.0	176.40
maneb	0.03	10	0.13	0.42	3	166.6	180.17
metalaxyl	0.19	40	0.51	0.05	150	105.0	295.74
metiram	0.03	10	0.18	0.31	7	109.6	127.12
propamocarb hydrochloride	0.03	10	0.14	0.50	30	60.0	100.66
sulfur	0.04	10	0.00	0.00	6	174.0	190.05
triphenyltin hydroxide	0.80	10	6.09	0.04	18	140.0	174.94

Table 1. BIOIPM Impact Factor Values

Formula: (0.25)*Acute toxicity + (0.5)*Impact on Microorganisms + (1.5)*Avian Toxicity + (0.5) Bee Toxicity + (1.0)*Impact on Resistance + (2.0)*Impact on Beneficials

Active Ingredient	Acute Toxicity	Micro-organism Impact	Avian Toxicity	Bee Toxicity	Impact on Resistance	Impacts on Beneficials	BIOIPM Impact Factor
OTHER							
maleic hydrazide	0.03	10	0.21	0.31	6	80.0	96.54
metam sodium	0.44	40	0.78	0.14	6	120.0	167.35
petroleum oils	0.03		0.00				0.00
sulfuric acid	0.13	10	0.00	0.50	6	40.0	0.00

Table 2. BIOIPM Impact Factor Values

Formula: (0.25)*Acute toxicity + (0.5)*Impact on Microorganisms + (1.5)*Avian Toxicity + (0.5) Bee Toxicity + (1.0)*Impact on Resistance + (2.0)*Impact on Beneficials

Active Ingredient	Acute Toxicity	Micro-organism Impact	Avian Toxicity	Bee Toxicity	Impact on Resistance	Impacts on Beneficials	BIOIPM Impact Factor
2,4-D	0.33	40	0.34	0.05	6	34.00	80.72
alachlor	0.13	40	0.14	0.31	6	82.60	129.18
azinphos-methyl	7.81	20	19.70	83.33	48	140.84	319.69
azoxystrobin	0.03	10	0.19	0.05	56	21.80	88.07
basic copper sulfate	0.05	20	0.96	0.50	5	21.80	48.31
chlorothalonil	0.03	10	0.23	0.03	5	100.00	115.29
copper ammonium	0.42	15	0.21	0.50	5	76.00	97.13
copper hydroxide	0.13	15	0.21	0.50	5	76.60	97.43
copper resinate	0.03	15	0.22	0.50	5	76.60	97.34
copper sulfate	0.42	20	0.19	0.50	5	21.80	47.91
cymoxanil	0.13	10	0.19	0.20	14	70.00	94.52
dimethoate	0.83	20	7.78	41.67	36	142.86	249.14
dimethomorph	0.03	10	0.22	0.05	14	40.00	64.30
diquat	0.54	10	2.53	0.31	6	80.00	99.38
disulfoton	48.08	30	53.99	83.34	54	133.34	402.74
endosulfan	1.56	20	4.72	0.70	63	122.70	212.69
endothal	2.45	10	1.54	0.50	6	80.00	100.49
esfenvalerate	1.87	15	0.34	83.33	192	133.34	425.88
ethoprophos	4.81	40	18.68	1.22	45	133.34	243.04
fonofos	15.63	40	15.72	1.52	23	111.12	206.48
glyphosate	0.03	40	0.19	0.05	6	82.60	128.87
imidacloprid	0.28	25	5.34	25.00	72	80.00	207.62
linuron	0.03	20	0.69	0.31	6	102.00	129.04
malathion	0.06	15	0.32	18.52	40	200.00	273.90
maleic hydrazide	0.03	10	0.21	0.31	6	80.00	96.54
mancozeb	0.03	10	0.06	0.31	10	156.00	176.40
maneb	0.03	10	0.13	0.42	3	166.60	180.17
metalaxyl	0.19	40	0.51	0.05	150	105.00	295.74
metam sodium	0.44	40	0.78	0.14	6	120.00	167.35
methamidophos	4.17	25	26.43	5.81	48	153.84	263.25
metiram	0.03	10	0.18	0.31	7	109.60	127.12
metolachlor	0.04	25	0.19	0.05	9	34.00	68.28
metribuzin	0.06	25	1.07	0.31	60	102.00	188.44
paraquat dichloride	0.83	30	0.51	0.10	6	130.00	167.45
pendimethalin	0.12	30	0.75	0.10	120	34.00	184.97

Table 2. BIOIPM Impact Factor Values

Formula: (0.25)*Acute toxicity + (0.5)*Impact on Microorganisms + (1.5)*Avian Toxicity + (0.5) Bee Toxicity + (1.0)*Impact on Resistance + (2.0)*Impact on Beneficials

Active Ingredient	Acute Toxicity	Micro-organism Impact	Avian Toxicity	Bee Toxicity	Impact on Resistance	Impacts on Beneficials	BIOIPM Impact Factor
permethrin	0.25	15	0.01	45.45	168	206.18	434.90
petroleum oils	0.03		0.00				0.00
phorate	50.00	40	140.14	18.52	24	200.00	472.66
phosmet	0.54	15	36.29	8.20	45	66.66	171.69
piperonyl butoxide	0.03	10	0.17	0.31	9	80.00	99.51
propamocarb hydrochloride	0.03	10	0.14	0.50	30	60.00	100.66
pyrethrins	0.08	15	0.05	38.46	108	200.00	361.59
rimsulfuron	0.03	35	0.28	0.05	120	102.00	257.35
sethoxydim	0.04	30	0.09	0.50	45	30.00	105.63
sulfur	0.04	10	0.00	0.00	6	174.00	190.05
sulfuric acid	0.13	10	0.00	0.50	6	40.00	0.00
triphenyltin hydroxide	0.80	10	6.09	0.04	18	140.00	174.94

Using the new BioIPM Impact formula, the soil insecticide phorate emerges as the most disruptive pesticide. This product was used on a very small portion of Wisconsin potato acreage, only 0.1 percent, and just in 1998. The NASS would not even report use of this insecticide since less than 1 percent of acres were treated with it.

Other highly disruptive compounds include the insecticides permethrin (435 index value), esfenvalerate (425), and disulfoton (403). These pesticides score so highly because of significant impacts on beneficials coupled with either significant bee or bird toxicity and a high risk of triggering resistance.

B. Establishing IPM System Ratio Values for Surveyed Farms

The IPM System ratio is an index composed of the Preventive Practice Points, or the PPP total in the numerator and total BioIPM Impact adjusted pesticide use in the denominator. Both the numerator and denominator are expressed as averages per acre in the surveyed field. In estimating the distribution of Wisconsin potato acreage along the IPM continuum, we assume that the IPM system ratio applicable to the surveyed field accurately represents the IPM system on place on all potato acres reported for the farm.

Tables 3 and 4 provide an overview of the derivation of the IPM system ratio on the 90 surveyed farms for which we have complete data. The data in Table 3 are ranked by IPM system ratio values and in Table 4, by “Farm Acres” in potatoes. The columns in each table include the unique farm identification code, the market for the potatoes grown on the field (fresh, processing, or seed), the acres in the surveyed potato field, total farm acres in potatoes, the PPP total, Scaled PPPs (10 times PPP total), BioIPM Impact adjusted pesticide use, and the IPM System Ratio value for the field.

The distribution of IPM System Ratio values was assessed in establishing the boundaries between no and low zones along the continuum, low and medium zones, and medium and high zones. Preliminary cut-off points have been set at 0.42, the lowest value in the high zone of the continuum. The top value in the medium zone is 0.36 – a substantial drop from the minimum value within the high zone. The lowest value in the medium zone is 0.23. The low IPM zone runs from IPM System Ratio values of 0.21 to 0.13, and the no IPM zone includes all farms with values of 0.11 below. In Table 3, the break points between zones are depicted by a blank cell across the table.

Table 3. Derivation of IPM System Ratio Values for 90 Surveyed Wisconsin Potato Farms in 1998, Ranked by IPM System Ratio Values per Acre

Farm ID	Market	Field Acres In Potatoes	Farm Acres in Potatoes	PPP Total per Acre	Scaled PPPs	BioIPM Impact Adjusted Pesticide Use	IPM System Ratio
887036590	processing	36	179	44	436	323	1.35
801388110	fresh	4	5	46	459	478	0.96
800580910	fresh	1	1	33	327	462	0.71
857001790	fresh	65	210	58	583	880	0.66
801642010	fresh	5	5	38	376	600	0.63
801064720	processing	5	30	44	437	772	0.57
800662590	fresh	3	18	30	303	648	0.47
801318200	fresh	60	150	40	404	888	0.46
800668790	seed	16	100	46	463	1,020	0.45
927668390	fresh	9	9	37	369	869	0.42
800075120	fresh	125	2,182	46	456	1,252	0.36
837014090	fresh	80	670	55	554	1,612	0.34
907209470	processing	130	1,441	48	480	1,424	0.34
801646690	fresh	6	18	28	285	856	0.33
897001150	processing	75	345	43	433	1,348	0.32
801675180	seed	150	900	52	520	1,651	0.31
801914980	processing	105	639	65	653	2,098	0.31
801487240	processing	120	858	61	609	1,960	0.31
801481550	fresh	3	3	33	332	1,094	0.30
801237680	fresh	85	435	55	553	1,884	0.29
800542610	seed	87	425	44	437	1,506	0.29
800773560	fresh	44	118	41	411	1,425	0.29
801899070	processing	154	964	67	667	2,387	0.28
927820370	fresh	140	1,254	48	480	1,766	0.27
800715660	processing	120	1,115	56	556	2,140	0.26
927665910	processing	35	85	46	456	1,842	0.25
937025680	processing	48	130	57	573	2,348	0.24
300014120	processing	70	927	46	463	2,016	0.23
801247800	fresh	30	405	38	383	1,688	0.23
801053760	fresh	5	5	32	324	1,508	0.21
827010200	processing	57	57	46	455	2,148	0.21
907011740	seed	65	450	55	548	2,610	0.21
801887060	processing	145	1,190	40	398	1,921	0.21
947014950	processing	23	293	49	486	2,381	0.20
847020590	processing	74	180	45	446	2,192	0.20
927816820	fresh	75	300	33	334	1,667	0.20
927019550	processing	80	900	60	598	2,988	0.20
800018340	processing	25	1,172	45	450	2,283	0.20
801622820	fresh	10	269	44	436	2,218	0.20

Table 3. Derivation of IPM System Ratio Values for 90 Surveyed Wisconsin Potato Farms in 1998, Ranked by IPM System Ratio Values per Acre

Farm ID	Market	Field Acres In Potatoes	Farm Acres in Potatoes	PPP Total per Acre	Scaled PPPs	BioIPM Impact Adjusted Pesticide Use	IPM System Ratio
887013360	fresh	30	341	42	422	2,173	0.19
300018390	processing	75	375	38	382	1,969	0.19
827005710	processing	60	285	40	404	2,111	0.19
877027670	seed	16	316	45	454	2,412	0.19
907026110	fresh	60	500	53	535	2,876	0.19
927427520	fresh	200	200	39	391	2,105	0.19
801966000	processing	33	120	47	468	2,544	0.18
801500980	fresh	120	335	52	522	2,839	0.18
801170290	processing	45	78	28	280	1,549	0.18
847060080	processing	70	170	43	429	2,383	0.18
857015340	processing	23	245	40	400	2,253	0.18
927388360	processing	6	175	39	394	2,225	0.18
801575770	processing	68	262	47	472	2,710	0.17
800998650	fresh	8	43	37	370	2,130	0.17
801378610	processing	147	561	46	460	2,649	0.17
801121840	fresh	18	30	35	350	2,045	0.17
300015460	fresh	55	488	39	392	2,313	0.17
827005610	seed	25	310	36	356	2,117	0.17
801099250	fresh	135	1,589	33	328	1,981	0.17
917035880	processing	50	75	36	357	2,178	0.16
917013290	processing	148	4,087	55	549	3,385	0.16
802005700	processing	60	60	42	422	2,619	0.16
801598140	fresh	20	20	36	358	2,238	0.16
801282550	fresh	40	40	28	285	1,861	0.15
801933790	processing	40	250	34	344	2,260	0.15
801016560	processing	68	142	40	397	2,607	0.15
957015220	fresh	86	86	36	356	2,354	0.15
887011970	processing	120	975	35	351	2,392	0.15
801526490	processing	139	1,311	35	353	2,410	0.15
801064330	processing	25	180	31	308	2,117	0.15
827010190	processing	35	235	39	389	2,674	0.15
801208460	processing	54	54	38	379	2,614	0.15
800013720	fresh	20	30	32	318	2,194	0.15
800999150	processing	37	950	48	485	3,457	0.14
801401020	seed	121	558	45	450	3,246	0.14
816005270	processing	55	183	31	311	2,247	0.14
847061510	processing	125	848	48	475	3,450	0.14
947011560	processing	32	230	37	366	2,752	0.13
907211560	fresh	14	34	38	379	2,895	0.13
801753360	processing	30	305	39	388	3,077	0.13
827005790	processing	39	624	46	464	4,136	0.11
877013880	fresh	35	95	25	255	2,286	0.11
957029240	fresh	15	57	29	293	2,665	0.11
800877050	processing	33	310	35	354	3,230	0.11
887011880	processing	16	355	29	289	2,638	0.11
801309540	fresh	13	267	29	288	2,682	0.11
801991290	processing	45	110	30	300	2,810	0.11
827005650	processing	65	805	32	321	3,033	0.11
800668780	processing	75	1,700	36	357	3,597	0.10
927816500	processing	35	180	21	211	2,214	0.10
801334310	fresh	10	10	36	364	4,912	0.07

Table 4. PPP Totals, BioIPM Impact Adjusted Pesticide Use and IPM System Ratio Values per Acre for 90 Surveyed Wisconsin Potato Farms in 1998, Ranked by Farm Acres in Potatoes

Farm ID	Market	Field Acres in Potatoes	Farm Acres in Potatoes	PPP Total per Acre	Scaled PPPs	BioIPM Impact Adjusted Pesticide Use	IPM System Ratio
917013290	processing	148	4,087	55	549	3,385	0.16
800075120	fresh	125	2,182	46	456	1,252	0.36
800668780	processing	75	1,700	36	357	3,597	0.10
801099250	fresh	135	1,589	33	328	1,981	0.17
907209470	processing	130	1,441	48	480	1,424	0.34
801526490	processing	139	1,311	35	353	2,410	0.15
927820370	fresh	140	1,254	48	480	1,766	0.27
801887060	processing	145	1,190	40	398	1,921	0.21
800018340	processing	25	1,172	45	450	2,283	0.20
800715660	processing	120	1,115	56	556	2,140	0.26
887011970	processing	120	975	35	351	2,392	0.15
801899070	processing	154	964	67	667	2,387	0.28
800999150	processing	37	950	48	485	3,457	0.14
300014120	processing	70	927	46	463	2,016	0.23
801675180	seed	150	900	52	520	1,651	0.31
927019550	processing	80	900	60	598	2,988	0.20
801487240	processing	120	858	61	609	1,960	0.31
847061510	processing	125	848	48	475	3,450	0.14
827005650	processing	65	805	32	321	3,033	0.11
837014090	fresh	80	670	55	554	1,612	0.34
801914980	processing	105	639	65	653	2,098	0.31
827005790	processing	39	624	46	464	4,136	0.11
801378610	processing	147	561	46	460	2,649	0.17
801401020	seed	121	558	45	450	3,246	0.14
907026110	fresh	60	500	53	535	2,876	0.19
300015460	fresh	55	488	39	392	2,313	0.17
907011740	seed	65	450	55	548	2,610	0.21
801237680	fresh	85	435	55	553	1,884	0.29
800542610	seed	87	425	44	437	1,506	0.29
801247800	fresh	30	405	38	383	1,688	0.23
300018390	processing	75	375	38	382	1,969	0.19
887011880	processing	16	355	29	289	2,638	0.11
897001150	processing	75	345	43	433	1,348	0.32
887013360	fresh	30	341	42	422	2,173	0.19
801500980	fresh	120	335	52	522	2,839	0.18
877027670	seed	16	316	45	454	2,412	0.19
827005610	seed	25	310	36	356	2,117	0.17
800877050	processing	33	310	35	354	3,230	0.11
801753360	processing	30	305	39	388	3,077	0.13
927816820	fresh	75	300	33	334	1,667	0.20
947014950	processing	23	293	49	486	2,381	0.20
827005710	processing	60	285	40	404	2,111	0.19
801622820	fresh	10	269	44	436	2,218	0.20
801309540	fresh	13	267	29	288	2,682	0.11
801575770	processing	68	262	47	472	2,710	0.17
801933790	processing	40	250	34	344	2,260	0.15
857015340	processing	23	245	40	400	2,253	0.18
827010190	processing	35	235	39	389	2,674	0.15
947011560	processing	32	230	37	366	2,752	0.13
857001790	fresh	65	210	58	583	880	0.66

Table 4. PPP Totals, BioIPM Impact Adjusted Pesticide Use and IPM System Ratio Values per Acre for 90 Surveyed Wisconsin Potato Farms in 1998, Ranked by Farm Acres in Potatoes

Farm ID	Market	Field Acres in Potatoes	Farm Acres in Potatoes	PPP Total per Acre	Scaled PPPs	BioIPM Impact Adjusted Pesticide Use	IPM System Ratio
927427520	fresh	200	200	39	391	2,105	0.19
816005270	processing	55	183	31	311	2,247	0.14
847020590	processing	74	180	45	446	2,192	0.20
801064330	processing	25	180	31	308	2,117	0.15
927816500	processing	35	180	21	211	2,214	0.10
887036590	processing	36	179	44	436	323	1.35
927388360	processing	6	175	39	394	2,225	0.18
847060080	processing	70	170	43	429	2,383	0.18
801318200	fresh	60	150	40	404	888	0.46
801016560	processing	68	142	40	397	2,607	0.15
937025680	processing	48	130	57	573	2,348	0.24
801966000	processing	33	120	47	468	2,544	0.18
800773560	fresh	44	118	41	411	1,425	0.29
801991290	processing	45	110	30	300	2,810	0.11
800668790	seed	16	100	46	463	1,020	0.45
877013880	fresh	35	95	25	255	2,286	0.11
957015220	fresh	86	86	36	356	2,354	0.15
927665910	processing	35	85	46	456	1,842	0.25
801170290	processing	45	78	28	280	1,549	0.18
917035880	processing	50	75	36	357	2,178	0.16
802005700	processing	60	60	42	422	2,619	0.16
827010200	processing	57	57	46	455	2,148	0.21
957029240	fresh	15	57	29	293	2,665	0.11
801208460	processing	54	54	38	379	2,614	0.15
800998650	fresh	8	43	37	370	2,130	0.17
801282550	fresh	40	40	28	285	1,861	0.15
907211560	fresh	14	34	38	379	2,895	0.13
801064720	processing	5	30	44	437	772	0.57
801121840	fresh	18	30	35	350	2,045	0.17
800013720	fresh	20	30	32	318	2,194	0.15
801598140	fresh	20	20	36	358	2,238	0.16
800662590	fresh	3	18	30	303	648	0.47
801646690	fresh	6	18	28	285	856	0.33
801334310	fresh	10	10	36	364	4,912	0.07
927668390	fresh	9	9	37	369	869	0.42
801388110	fresh	4	5	46	459	478	0.96
801642010	fresh	5	5	38	376	600	0.63
801053760	fresh	5	5	32	324	1,508	0.21
801481550	fresh	3	3	33	332	1,094	0.30
800580910	fresh	1	1	33	327	462	0.71
			40,027				

Tables 3 and 4 provide several insights regarding the differences among the largest commercial potato farms in Wisconsin. Despite the fact there are almost 40 percent more farms growing potatoes for processing compared to the fresh market, there are 7 farms growing fresh market potatoes in the high zone compared to two growing for the processing market. Some of these farms are quite small, so these results must be interpreted with caution. Later, we provide other comparison between commercial-scale fresh and processing market producers.

Among the 10 farms with 1,000 acres or more in potatoes (see top Table 4), IPM System Ratio values range from a high of 0.36, just below the high zone along the continuum, to a low of 0.10, the second lowest value among the 90 farms surveyed. A review of the PPP totals and pesticide use on these farms shows clearly that variation in pesticide use accounts for a greater share of the variability in IPM System Ratios than does variation in PPP totals. Among farms with over 1,000 acres in potatoes, there is a 1.7-fold difference between the farm with the maximum PPP total and the minimum. The range in "BioIPM Impact Adjusted Pesticide Use" is 2.9.

Toward the bottom of Table 4 the 12 smallest farms are all growing for the fresh market. It is likely that at least a few of these are producing for farm stands or to meet family needs.

Assessment of the 1998 IPM Baseline

Further insights into the distribution of, and differences across farms in the four zones along the IPM continuum are evident in Tables 5 and 6. Table 5 reports descriptive statistics of farms falling within each zone including average acres in potatoes, average Scaled PPP totals, average BioIPM Adjusted Pesticide Use, and average IPM System Ratio values. Table 5 reports simple averages, not weighted by the acres of potatoes in different farms. Hence a farm with 20 acres in potatoes affects the average value as much as a farm with 1,000.

Table 6 corrects this shortcoming by reporting average PPP, pesticide use and IPM system ratio values weighted by "Farm Acres in Potatoes." This table also shows the percent of surveyed acres falling within each of the four zones. The data in Table 6 offer the best summary of the basic characteristics of farms in the four zones along the IPM continuum. Key findings include –

- Less than 2 percent of the surveyed acreage is in the high, or biointensive zone along the IPM continuum, although three farms accounting for another 10 percent of surveyed acres are close to entering this zone.

- About one-third of farms are in the medium zone, and just under 55 percent are in the low zone. Over 11 percent are still managing pests with heavy reliance on pesticides and in most cases, minimal effort to prevent pest pressure.

- The pesticides applied on farms in the medium zone have BioIPM Impact Adjusted Pesticide Use values 2.3 times higher than farms that have made it into the biointensive IPM zone along the continuum. Clearly, some farms have managed to substantially lessen pest pressure through multitactic IPM systems.

- Farms in the medium zone actually have higher PPP totals than farms in the high zone, but have lower IPM System Ratio values because of their much greater reliance on pesticides. In all likelihood, the farms in the high zone along the continuum either fell in parts of the state with markedly lower pest pressure, or more likely have been managing

their operations with high-level IPM systems for long enough to begin to significantly reduce background pest population levels and/or diversify populations of beneficials.

- The differences between the weighted average IPM System Ratio and pesticide use values in the high zone compared to the low are striking – a 7.5-fold difference and 4.4-fold difference respectively.

Table 5. Potato Acres in the Four Zones Along the IPM Continuum and Average PPP Totals, BioIPM Impact Adjusted Pesticide Use, and IPM System Ratio Values within the Zones, Crop year 1998

Farm ID	Market	Field Acres in Potatoes	Farm Acres in Potatoes	PPP Total per Acre	Scaled PPPs	BioIPM Impact Adjusted Pesticide Use	IPM System Ratio	Acres Weighted PPPs	Acres Weighted Pest Use	Acres Weighted IPM System Ratio
887036590	processing	36	179	44	436	323	1.35	110.65	82.03	0.34
801388110	fresh	4	5	46	459	478	0.96	3.25	3.38	0.01
800580910	fresh	1	1	33	327	462	0.71	0.46	0.65	0.00
857001790	fresh	65	210	58	583	880	0.66	173.28	261.49	0.20
801642010	fresh	5	5	38	376	600	0.63	2.66	4.25	0.00
801064720	processing	5	30	44	437	772	0.57	18.56	32.76	0.02
800662590	fresh	3	18	30	303	648	0.47	7.72	16.50	0.01
801318200	fresh	60	150	40	404	888	0.46	85.81	188.40	0.10
800668790	seed	16	100	46	463	1,020	0.45	65.50	144.25	0.06
927668390	fresh	9	9	37	369	869	0.42	4.70	11.07	0.01
Total Acres in High Zone and Average PPP, Pesticide Use, IPM System Ratio Values			**707**		**416**	**694**	**0.67**	**472.59**	**744.79**	**0.75**
800075120	fresh	125	2182	46	456	1,252	0.36	77.02	211.54	0.06
837014090	fresh	80	670	55	554	1,612	0.34	28.73	83.63	0.02
907209470	processing	130	1441	48	480	1,424	0.34	53.57	158.93	0.04
801646690	fresh	6	18	28	285	856	0.33	0.40	1.19	0.00
897001150	processing	75	345	43	433	1,348	0.32	11.58	36.02	0.01
801675180	seed	150	900	52	520	1,651	0.31	36.21	115.06	0.02
801914980	processing	105	639	65	653	2,098	0.31	32.29	103.81	0.02
801487240	processing	120	858	61	609	1,960	0.31	40.47	130.20	0.02
801481550	fresh	3	3	33	332	1,094	0.30	0.08	0.25	0.00
801237680	fresh	85	435	55	553	1,884	0.29	18.63	63.47	0.01
800542610	seed	87	425	44	437	1,506	0.29	14.38	49.56	0.01
800773560	fresh	44	118	41	411	1,425	0.29	3.76	13.02	0.00
801899070	processing	154	964	67	667	2,387	0.28	49.76	178.18	0.02
927820370	fresh	140	1254	48	480	1,766	0.27	46.66	171.48	0.03
800715660	processing	120	1115	56	556	2,140	0.26	47.98	184.78	0.02
927665910	processing	35	85	46	456	1,842	0.25	3.00	12.12	0.00
937025680	processing	48	130	57	573	2,348	0.24	5.76	23.63	0.00
300014120	processing	70	927	46	463	2,016	0.23	33.27	144.70	0.02
801247800	fresh	30	405	38	383	1,688	0.23	12.02	52.94	0.01
Total Acres in Medium Zone and Average PPP, Pesticide Use, IPM System Ratio Values			**12914**		**489**	**1,700**	**0.29**	**515.56**	**1734.55**	**0.30**
801053760	fresh	5	5	32	324	1,508	0.21	0.07	0.31	0.00
827010200	processing	57	57	46	455	2,148	0.21	1.19	5.59	0.00
907011740	seed	65	450	55	548	2,610	0.21	11.25	53.65	0.00
801887060	processing	145	1190	40	398	1,921	0.21	21.63	104.44	0.01
947014950	processing	23	293	49	486	2,381	0.20	6.50	31.87	0.00
847020590	processing	74	180	45	446	2,192	0.20	3.67	18.03	0.00
927816820	fresh	75	300	33	334	1,667	0.20	4.58	22.85	0.00
927019550	processing	80	900	60	598	2,988	0.20	24.58	122.84	0.01
800018340	processing	25	1172	45	450	2,283	0.20	24.10	122.26	0.01
801622820	fresh	10	269	44	436	2,218	0.20	5.36	27.28	0.00
887013360	fresh	30	341	42	422	2,173	0.19	6.57	33.84	0.00

Table 5. Potato Acres in the Four Zones Along the IPM Continuum and Average PPP Totals, BioIPM Impact Adjusted Pesticide Use, and IPM System Ratio Values within the Zones, Crop year 1998

Farm ID	Market	Field Acres in Potatoes	Farm Acres in Potatoes	PPP Total per Acre	Scaled PPPs	BioIPM Impact Adjusted Pesticide Use	IPM System Ratio	Acres Weighted PPPs	Acres Weighted Pest Use	Acres Weighted IPM System Ratio
300018390	processing	75	375	38	382	1,969	0.19	6.54	33.73	0.00
827005710	processing	60	285	40	404	2,111	0.19	5.26	27.48	0.00
877027670	seed	16	316	45	454	2,412	0.19	6.56	34.86	0.00
907026110	fresh	60	500	53	535	2,876	0.19	12.21	65.70	0.00
927427520	fresh	200	200	39	391	2,105	0.19	3.57	19.23	0.00
801966000	processing	33	120	47	468	2,544	0.18	2.57	13.94	0.00
801500980	fresh	120	335	52	522	2,839	0.18	7.99	43.45	0.00
801170290	processing	45	78	28	280	1,549	0.18	1.00	5.52	0.00
847060080	processing	70	170	43	429	2,383	0.18	3.33	18.51	0.00
857015340	processing	23	245	40	400	2,253	0.18	4.48	25.22	0.00
927388360	processing	6	175	39	394	2,225	0.18	3.15	17.78	0.00
801575770	processing	68	262	47	472	2,710	0.17	5.64	32.44	0.00
800998650	fresh	8	43	37	370	2,130	0.17	0.73	4.18	0.00
801378610	processing	147	561	46	460	2,649	0.17	11.80	67.90	0.00
801121840	fresh	18	30	35	350	2,045	0.17	0.48	2.80	0.00
300015460	fresh	55	488	39	392	2,313	0.17	8.73	51.56	0.00
827005610	seed	25	310	36	356	2,117	0.17	5.05	29.98	0.00
801099250	fresh	135	1589	33	328	1,981	0.17	23.81	143.73	0.01
917035880	processing	50	75	36	357	2,178	0.16	1.22	7.46	0.00
917013290	processing	148	4087	55	549	3,385	0.16	102.54	631.86	0.03
802005700	processing	60	60	42	422	2,619	0.16	1.16	7.18	0.00
801598140	fresh	20	20	36	358	2,238	0.16	0.33	2.04	0.00
801282550	fresh	40	40	28	285	1,861	0.15	0.52	3.40	0.00
801933790	processing	40	250	34	344	2,260	0.15	3.93	25.81	0.00
801016560	processing	68	142	40	397	2,607	0.15	2.56	16.85	0.00
957015220	fresh	86	86	36	356	2,354	0.15	1.40	9.25	0.00
887011970	processing	120	975	35	351	2,392	0.15	15.64	106.53	0.01
801526490	processing	139	1311	35	353	2,410	0.15	21.16	144.33	0.01
801064330	processing	25	180	31	308	2,117	0.15	2.53	17.40	0.00
827010190	processing	35	235	39	389	2,674	0.15	4.17	28.71	0.00
801208460	processing	54	54	38	379	2,614	0.15	0.94	6.45	0.00
800013720	fresh	20	30	32	318	2,194	0.15	0.44	3.01	0.00
800999150	processing	37	950	48	485	3,457	0.14	21.04	150.02	0.01
801401020	seed	121	558	45	450	3,246	0.14	11.46	82.76	0.00
816005270	processing	55	183	31	311	2,247	0.14	2.60	18.78	0.00
847061510	processing	125	848	48	475	3,450	0.14	18.42	133.63	0.01
947011560	processing	32	230	37	366	2,752	0.13	3.84	28.91	0.00
907211560	fresh	14	34	38	379	2,895	0.13	0.59	4.50	0.00
801753360	processing	30	305	39	388	3,077	0.13	5.40	42.86	0.00
Total Acres in Low Zone and Average PPP, Pesticide Use, IPM System Ratio Values			**21892**		**406**	**2,407**	**0.17**	**444.30**	**2652.70**	**0.17**
827005790	processing	39	624	46	464	4,136	0.11	64.11	571.89	0.02
877013880	fresh	35	95	25	255	2,286	0.11	5.36	48.11	0.00
957029240	fresh	15	57	29	293	2,665	0.11	3.70	33.66	0.00
800877050	processing	33	310	35	354	3,230	0.11	24.34	221.84	0.01
887011880	processing	16	355	29	289	2,638	0.11	22.76	207.53	0.01
801309540	fresh	13	267	29	288	2,682	0.11	17.06	158.84	0.01
801991290	processing	45	110	30	300	2,810	0.11	7.31	68.50	0.00
827005650	processing	65	805	32	321	3,033	0.11	57.24	541.05	0.02
800668780	processing	75	1700	36	357	3,597	0.10	134.44	1355.02	0.04
927816500	processing	35	180	21	211	2,214	0.10	8.40	88.29	0.00
801334310	fresh	10	10	36	364	4,912	0.07	0.81	10.88	0.00
Total Acres in No IPM Zone and Average PPP, Pesticide Use, IPM System Ratio Values			**4513**		**318**	**3,109**	**0.10**	**346**	**3,306**	**0.10**
			40,027							

Table 6. An Overview of the 1998 Wisconsin Potato IPM Baseline: Weighted Average PPP Totals, BioIPM Impact Adjusted Pesticide Use, and IPM System Ratio Values within the Four Zones Along the IPM Continuum [Weighted by "Farm Acres in Potatoes"]

Zones Along the IPM Continuum	Number of Farms	Farm Acres in Potatoes	Percent Total Surveyed Acres	Weighted Average Scaled PPPs	Weighted Average BioIPM Impact Adjusted Pesticide Use	Weighted Average IPM System Ratio
High	10	707	1.8%	473	745	0.75
Medium	19	12,914	32.3%	516	1,735	0.30
Low	50	21,892	54.7%	444	2,653	0.17
No	11	4,513	11.3%	346	3,306	0.10
Totals	**90**	**40,027**				

Goals for Crop Years 2002 and 2007

The WWF-WPVGA Memorandum of Understanding sets forth five-year and ten-year IPM adoption goals. By crop year 2002, the goal calls for a doubling in the percentage of acres in the biointensive zone. Based on the 1998 baseline, this goal translates into at least 3.6 percent of acres under biointensive IPM.

The second key goal by crop year 2002 is for 75 percent the acreage in potatoes to be managed within the high or medium zones. This goal corresponds to the Clinton Administration's goal to get 75 percent of the nation’s cropland acreage under medium- and high-level IPM by 2001. In 1998, our preliminary estimate of acreage along the continuum suggests that fewer than 35 percent of acres currently exist in these two zones. Accordingly, about two-thirds of the acreage in the low and no zones must shift into the medium and high zones to meet this goal. Achieving this goal will require both significant shifts away from higher-risk pesticides and greater reliance on preventive practices. But such changes are clearly feasible, since if all farms increased their IPM System Ration values by about 30 to 40 percent, the required acreage would shift into the medium zone.

By crop year 2007 the MOU calls for no more than 10 percent of acres to be managed under the low-level IPM and for 50 percent of acreage to reach the biointensive zone. While ambitious, this goal is also achievable given the relatively small changes required to shift considerable acreage above the high IPM zone cut-off point. Across all farms now in the medium zone and low zones, an average 75 percent increase in IPM system ration values would come close to achieving even this goal. Some farms would need to nearly double their IPM system ratio values. This could be accomplished by eliminating three to five applications of high-risk pesticides, reducing BioIPM Impact Adjusted Pesticide Use by over 30 to 40 percent while adopting enough additional preventive practices to increase PPP totals by 40 to 50 percent.

Impacts of Farm Size and Type of Potato Operation

A series of tables follow that provide a first assessment of some of the differences in pesticide use as a function of farm size and type of market. Additional discussion of these tables will be added in the final version of this paper. Key findings include the major differences in pesticide use between fresh and processing markets – clearly, processing standards are pushing reliance higher, and hence suggests the project should focus greater effort on trying to convince processors to change their quality control provisions and guidelines to growers.

More in depth analysis is also needed of those clusters of farms that have begun to implement area-wide population suppression tactics. Detailed assessment of the reasons why some farms have managed to reduce pesticide use so much relative to industry averages should lead to insights regarding seminal preventive IPM practices. These insights will, in turn, provide the project team an empirical basis to adjust the weights assigned to different preventive practices.

Table 7. Farms with Greater than 160 Acres in Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	Toxicity Units per acre	Pounds Applied per Acre	Market Type
FUNGICIDES			
827005790	3,091.66	21.23	processing
917013290	2,770.24	18.56	processing
800999150	2,641.07	16.83	processing
800668780	2,633.78	16.92	processing
847061510	2,450.94	16.35	processing
827005650	2,446.01	14.98	processing
801575770	2,344.39	15.59	processing
800877050	2,312.34	15.36	processing
801500980	2,288.83	13.42	fresh
947011560	2,252.39	15.44	processing
801309540	2,222.12	12.98	fresh
907026110	2,211.98	17.05	fresh
800018340	2,191.75	13.77	processing
801064330	2,116.81	12.00	processing
927816500	2,116.81	12.00	processing
801899070	2,052.11	12.95	processing
801378610	2,048.61	17.04	processing
801933790	2,002.20	12.57	processing
827010190	1,999.04	12.96	processing
816005270	1,989.03	15.69	processing
927019550	1,954.40	15.70	processing
857015340	1,947.35	13.66	processing
827005710	1,943.83	12.62	processing
927388360	1,884.81	13.63	processing
887013360	1,859.01	15.22	fresh
801753360	1,842.95	14.98	processing

Table 7. Farms with Greater than 160 Acres in Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	Toxicity Units per acre	Pounds Applied per Acre	Market Type
887011880	1,832.46	14.13	processing
801914980	1,832.38	14.36	processing
801487240	1,764.01	10.00	processing
847060080	1,741.20	12.29	processing
801237680	1,642.01	13.90	fresh
947014950	1,636.58	11.98	processing
927427520	1,615.85	10.39	fresh
887011970	1,608.99	12.67	processing
300014120	1,590.24	13.44	processing
847020590	1,563.78	10.25	processing
800715660	1,551.09	10.15	processing
801622820	1,510.28	10.10	fresh
837014090	1,493.09	12.05	fresh
801099250	1,490.13	11.05	fresh
801247800	1,460.85	9.51	fresh
300018390	1,456.17	12.09	processing
801526490	1,442.22	12.51	processing
927820370	1,384.16	9.45	fresh
300015460	1,352.35	11.04	fresh
927816820	1,263.42	7.16	fresh
800075120	1,234.81	7.00	fresh
801887060	1,170.92	10.24	processing
907209470	1,123.22	7.48	processing
897001150	1,071.90	8.67	processing
857001790	818.07	7.23	fresh
887036590	230.00	2.00	processing
800999150	19.04	0.20	processing
TOTAL FUNGICIDE	**94,513.62**	**660.84**	
Average Fungicide	**1,783.28**	**12.47**	
HERBICIDE			
927019550	564.06	3.62	processing
847061510	415.54	2.30	processing
801309540	372.24	2.35	fresh
887011880	288.00	2.00	processing
827010190	280.06	1.50	processing
801378610	265.15	1.42	processing
800715660	255.77	1.37	processing
801575770	244.72	1.31	processing
947014950	243.75	2.25	processing
907026110	232.01	1.25	fresh
897001150	230.62	1.24	processing
947011560	230.62	1.24	processing
801526490	226.13	1.20	processing
801914980	223.53	1.20	processing
800877050	216.28	1.16	processing
300014120	208.01	1.12	processing
887011970	202.65	1.31	processing
917013290	201.86	1.24	processing

Table 7. Farms with Greater than 160 Acres in Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	Toxicity Units per acre	Pounds Applied per Acre	Market Type
927816820	187.44	0.99	fresh
927388360	177.30	1.38	processing
927820370	170.63	0.90	fresh
827005710	167.32	1.13	processing
800075120	161.00	0.95	fresh
300018390	157.62	0.75	processing
801500980	157.14	0.83	fresh
827005790	155.46	0.83	processing
300015460	137.24	1.35	fresh
800999150	131.56	1.11	processing
801887060	124.90	0.65	processing
887013360	113.06	0.60	fresh
801622820	110.01	0.58	fresh
827005650	109.29	1.05	processing
801247800	106.00	0.56	fresh
801099250	100.71	0.53	fresh
927816500	96.78	0.75	processing
800668780	94.49	0.58	processing
847020590	93.28	0.50	processing
887036590	93.28	0.50	processing
907209470	92.83	0.48	processing
801899070	84.07	0.53	processing
801487240	70.67	0.38	processing
801933790	70.67	0.38	processing
816005270	70.67	0.38	processing
847060080	70.67	0.38	processing
857015340	70.67	0.38	processing
801753360	70.54	0.52	processing
801237680	42.40	0.23	fresh
927427520	39.35	0.20	fresh
800018340	38.66	0.30	processing
TOTAL HERBICIDE	**8,266.66**	**49.69**	
Average Herbicide	**172.22**	**1.04**	
INSECTICIDE			
801753360	1,224.88	4.55	processing
827005790	912.81	3.71	processing
300015460	889.90	3.73	fresh
800668780	868.92	3.40	processing
801526490	741.80	3.25	processing
800999150	728.39	3.85	processing
800877050	700.92	3.27	processing
801887060	690.64	2.97	processing
947014950	603.03	4.09	processing
801622820	597.66	2.54	fresh
847061510	583.41	2.30	processing
887011970	580.30	1.66	processing
847060080	571.30	2.43	processing
801500980	566.74	2.28	fresh

Table 7. Farms with Greater than 160 Acres in Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	Toxicity Units per acre	Pounds Applied per Acre	Market Type
801378610	552.68	1.80	processing
927019550	536.15	2.02	processing
847020590	535.27	1.98	processing
827005650	527.85	1.74	processing
887011880	517.83	2.29	processing
927427520	449.92	1.92	fresh
907026110	432.51	2.03	fresh
917013290	412.46	1.23	processing
827010190	395.00	2.37	processing
801099250	389.99	1.91	fresh
300018390	355.17	1.60	processing
800715660	333.32	0.77	processing
947011560	269.05	0.61	processing
801899070	250.78	1.09	processing
857015340	235.11	0.33	processing
300014120	217.52	0.29	processing
927816820	216.32	0.50	fresh
927820370	211.55	0.70	fresh
907209470	208.27	0.98	processing
887013360	200.52	0.42	fresh
801237680	199.98	0.25	fresh
801933790	187.50	0.23	processing
816005270	187.50	0.23	processing
927388360	162.46	0.20	processing
801309540	130.77	0.73	fresh
801487240	124.94	0.16	processing
801247800	121.38	0.29	fresh
801575770	121.33	0.66	processing
837014090	118.93	0.69	fresh
857001790	62.29	0.25	fresh
800018340	52.68	0.12	processing
897001150	45.96	0.30	processing
801914980	42.16	0.10	processing
800075120	13.16	0.03	fresh
TOTAL INSECTICIDE	**19,079.00**	**74.84**	

Table 8. Farms Producing Fewer than 160 Acres of Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	Toxicity Units per Acre	Pounds Applied per Acre	Market Type
FUNGICIDES			
801334310	2,822.41	16.00	fresh
957029240	2,564.24	16.88	fresh
801991290	2,312.07	16.26	processing
801966000	2,069.80	13.09	processing

Table 8. Farms Producing Fewer than 160 Acres of Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	Toxicity Units per Acre	Pounds Applied per Acre	Market Type
800998650	2,054.00	12.73	fresh
937025680	1,897.37	12.65	processing
957015220	1,851.24	14.47	fresh
802005700	1,844.40	11.63	processing
827010200	1,792.67	11.62	processing
877013880	1,733.44	12.72	fresh
917035880	1,696.45	11.42	processing
907211560	1,637.90	13.30	fresh
801282550	1,635.10	11.80	fresh
801016560	1,611.27	11.46	processing
801121840	1,562.08	9.38	fresh
801053760	1,411.21	8.00	fresh
801208460	1,359.71	11.59	processing
800773560	1,351.29	7.50	fresh
927665910	1,247.94	9.10	processing
801598140	1,186.36	9.61	fresh
801481550	1,058.40	6.00	fresh
801170290	1,051.62	9.12	processing
800013720	926.10	5.25	fresh
801318200	727.59	5.41	fresh
927668390	578.89	4.43	fresh
801064720	564.48	3.20	processing
801646690	282.24	1.60	fresh
801642010	259.39	2.25	fresh
800662590	190.22	1.65	fresh
TOTAL FUNGICIDE	**41,279.90**	**280.09**	
Average Fungicide	**1,423.44**	**9.66**	
HERBICIDE			
801646690	498.97	3.00	fresh
800580910	462.42	2.50	fresh
801388110	287.15	2.15	fresh
800662590	258.07	2.00	fresh
937025680	232.77	1.25	processing
802005700	223.26	1.20	processing
801016560	209.39	1.13	processing
800013720	202.65	1.31	fresh
801642010	189.26	1.25	fresh
801282550	181.45	1.20	fresh
957015220	167.32	1.27	fresh
907211560	160.25	1.09	fresh
801318200	145.04	1.13	fresh
801121840	106.00	0.56	fresh
801598140	106.00	0.56	fresh
801991290	97.29	0.51	processing
801053760	96.78	0.75	fresh
801170290	94.69	0.50	processing
801208460	94.69	0.50	processing
917035880	94.69	0.50	processing

Table 8. Farms Producing Fewer than 160 Acres of Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]			
Farm	**Toxicity Units per Acre**	**Pounds Applied per Acre**	**Market Type**
827010200	93.28	0.50	processing
927665910	93.28	0.50	processing
800773560	70.67	0.38	fresh
801064720	70.67	0.38	processing
927668390	70.67	0.38	fresh
877013880	66.45	0.44	fresh
801334310	47.11	0.25	fresh
801966000	29.58	0.15	processing
TOTAL HERBICIDE	**4,449.86**	**27.32**	
Average Herbicide	**158.92**	**0.98**	
INSECTICIDE			
801334310	2,042.66	5.78	fresh
907211560	1,270.51	5.42	fresh
801208460	1,159.24	5.13	processing
800013720	1,065.42	2.28	fresh
801598140	945.69	2.34	fresh
801016560	786.79	3.10	processing
802005700	551.68	2.92	processing
927665910	500.65	1.83	processing
877013880	485.68	2.16	fresh
801966000	444.32	1.40	processing
801170290	402.61	1.57	processing
801991290	401.00	1.63	processing
917035880	386.41	2.05	processing
801121840	377.05	1.27	fresh
957015220	335.68	1.26	fresh
827010200	262.14	0.57	processing
927668390	219.92	0.70	fresh
937025680	217.52	0.29	processing
800662590	199.98	0.25	fresh
801388110	191.12	0.83	fresh
801642010	151.70	0.36	fresh
801064720	136.97	0.26	processing
957029240	101.15	0.24	fresh
800998650	75.85	0.18	fresh
801646690	74.95	0.09	fresh
801282550	44.25	0.10	fresh
801481550	35.14	0.08	fresh
801318200	15.37	0.04	fresh
800773560	2.64	0.01	fresh

Table 9. Fresh Market Farms Producing More Than 160 Acres of Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms

Farm	Toxicity Units per Acre	Pounds Applied per Acre
FUNGICIDES		
801500980	2,288.83	13.42
801309540	2,222.12	12.98
907026110	2,211.98	17.05
887013360	1,859.01	15.22
801237680	1,642.01	13.90
927427520	1,615.85	10.39
801622820	1,510.28	10.10
837014090	1,493.09	12.05
801099250	1,490.13	11.05
801247800	1,460.85	9.51
927820370	1,384.16	9.45
300015460	1,352.35	11.04
927816820	1,263.42	7.16
800075120	1,234.81	7.00
857001790	818.07	7.23
TOTAL FUNGICIDE	**23,846.94**	**167.55**
Average Fungicide	**1,589.80**	**11.17**
HERBICIDE		
801309540	372.24	2.35
907026110	232.01	1.25
927816820	187.44	0.99
927820370	170.63	0.90
800075120	161.00	0.95
801500980	157.14	0.83
300015460	137.24	1.35
887013360	113.06	0.60
801622820	110.01	0.58
801247800	106.00	0.56
801099250	100.71	0.53
801237680	42.40	0.23
927427520	39.35	0.20
TOTAL HERBICIDE	**1,929.22**	**11.32**
Average Herbicide	**137.80**	**0.81**
INSECTICIDE		
300015460	889.90	3.73
801622820	597.66	2.54
801500980	566.74	2.28
927427520	449.92	1.92
907026110	432.51	2.03
801099250	389.99	1.91
927816820	216.32	0.50
927820370	211.55	0.70
887013360	200.52	0.42
801237680	199.98	0.25
801309540	130.77	0.73
801247800	121.38	0.29
837014090	118.93	0.69
857001790	62.29	0.25
800075120	13.16	0.03
TOTAL INSECTICIDE	**4,601.61**	**18.25**
Average Insecticide	**306.77**	**1.22**

Table 10. Processing Potato Farms Producing More than 160 Acres of Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	toxicity per acre	lbs applied per acre
FUNGICIDES		
827005790	3,091.66	21.23
917013290	2,770.24	18.56
800999150	2,641.07	16.83
800668780	2,633.78	16.92
847061510	2,450.94	16.35
827005650	2,446.01	14.98
801575770	2,344.39	15.59
800877050	2,312.34	15.36
947011560	2,252.39	15.44
800018340	2,191.75	13.77
801064330	2,116.81	12.00
927816500	2,116.81	12.00
801899070	2,052.11	12.95
801378610	2,048.61	17.04
801933790	2,002.20	12.57
827010190	1,999.04	12.96
816005270	1,989.03	15.69
927019550	1,954.40	15.70
857015340	1,947.35	13.66
827005710	1,943.83	12.62
927388360	1,884.81	13.63
801753360	1,842.95	14.98
887011880	1,832.46	14.13
801914980	1,832.38	14.36
801487240	1,764.01	10.00
847060080	1,741.20	12.29
947014950	1,636.58	11.98
887011970	1,608.99	12.67
300014120	1,590.24	13.44
847020590	1,563.78	10.25
800715660	1,551.09	10.15
300018390	1,456.17	12.09
801526490	1,442.22	12.51
801887060	1,170.92	10.24
907209470	1,123.22	7.48
897001150	1,071.90	8.67
887036590	230.00	2.00
800999150	19.04	0.20
TOTAL FUNGICIDE	**70,666.68**	**493.29**
Average Fungicide	**1,859.65**	**12.98**
HERBICIDE		
927019550	564.06	3.62
847061510	415.54	2.30
887011880	288.00	2.00
827010190	280.06	1.50

Table 10. Processing Potato Farms Producing More than 160 Acres of Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	toxicity per acre	lbs applied per acre
801378610	265.15	1.42
800715660	255.77	1.37
801575770	244.72	1.31
947014950	243.75	2.25
897001150	230.62	1.24
947011560	230.62	1.24
801526490	226.13	1.20
801914980	223.53	1.20
800877050	216.28	1.16
300014120	208.01	1.12
887011970	202.65	1.31
917013290	201.86	1.24
927388360	177.30	1.38
827005710	167.32	1.13
300018390	157.62	0.75
827005790	155.46	0.83
800999150	131.56	1.11
801887060	124.90	0.65
827005650	109.29	1.05
927816500	96.78	0.75
800668780	94.49	0.58
847020590	93.28	0.50
887036590	93.28	0.50
907209470	92.83	0.48
801899070	84.07	0.53
801487240	70.67	0.38
801933790	70.67	0.38
816005270	70.67	0.38
847060080	70.67	0.38
857015340	70.67	0.38
801753360	70.54	0.52
800018340	38.66	0.30
TOTAL HERBICIDE	**6,337.44**	**38.37**
Average Herbicide	**176.04**	**1.07**
INSECTICIDE		
300014120	217.52	0.29
300018390	355.17	1.60
800018340	52.68	0.12
800668780	868.92	3.40
800715660	333.32	0.77
800877050	700.92	3.27
800999150	728.39	3.85
801378610	552.68	1.80
801487240	124.94	0.16
801526490	741.80	3.25
801575770	121.33	0.66
801753360	1,224.88	4.55

Table 10. Processing Potato Farms Producing More than 160 Acres of Potatoes: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	toxicity per acre	lbs applied per acre
801887060	690.64	2.97
801899070	250.78	1.09
801914980	42.16	0.10
801933790	187.50	0.23
816005270	187.50	0.23
827005650	527.85	1.74
827005790	912.81	3.71
827010190	395.00	2.37
847020590	535.27	1.98
847060080	571.30	2.43
847061510	583.41	2.30
857015340	235.11	0.33
887011880	517.83	2.29
887011970	580.30	1.66
897001150	45.96	0.30
907209470	208.27	0.98
917013290	412.46	1.23
927019550	536.15	2.02
927388360	162.46	0.20
947011560	269.05	0.61
947014950	603.03	4.09
TOTAL INSECTICIDE	**14,477.39**	**56.59**
Average Insecticide	**438.71**	**1.71**

Table 11. Seed Potato Farms: Toxicity Units per Acre by Type of Pesticide and Pounds Applied, Ranked by Toxicity Units per Acre [Excludes Seed Potato Farms]

Farm	Toxicity Units per Acre	Pounds Applied per Acre
FUNGICIDES		
907011740	2,284.22	17.70
827005610	1,827.98	11.09
801401020	1,821.69	13.07
877027670	1,376.72	8.89
800542610	1,329.46	8.95
801675180	1,322.04	11.47
800668790	769.19	6.67
TOTAL FUNGICIDE	**10,731.29**	**77.83**
Average Fungicide	**1,533.04**	**11.12**
HERBICIDE		
877027670	847.69	6.02
801401020	793.23	5.49
801675180	129.04	1.00
907011740	106.00	0.56
800542610	96.65	0.75
827005610	76.34	0.53
800668790	50.65	0.26
TOTAL HERBICIDE	**2,099.60**	**14.61**
Average Herbicide	**299.94**	**2.09**
INSECTICIDE		
801401020	631.26	2.24
907011740	219.74	0.30
827005610	212.81	0.79
800668790	199.98	0.25
801675180	199.98	0.25
877027670	187.50	0.23
800542610	79.70	0.30
TOTAL INSECTICIDE	**1,730.96**	**4.36**
Average Insecticide	**247.28**	**0.62**

Table 12. Differences in the Average Toxicity Units and Pounds Applied per Acre by Type of Pesticide and Size of Farm, 90 Farms Producing Potatoes in Wisconsin in 1998

	Fungicide Toxicity per Acre	Fungicide Pounds per Acre	Herbicide Toxicity per Acre	Herbicide Pounds per Acre	Insecticide Toxicity per Acre	Insecticide Pounds per Acre
Farms with more than 160 acres	1,783.28	12.47	172.22	1.04	397.48	1.56
Processing	1,859.65	12.98	176.04	1.07	438.71	1.71
Fresh	1,589.80	11.17	137.80	0.81	306.80	1.22
Seed	1,533.04	11.12	299.94	2.09	247.28	0.62
Farms with less than 160 acres	1,423.44	9.66	158.92	0.98	444.28	1.52