Atrazine and Water Quality: An Updated CEEPES Analysis

CEEPES Atrazine Project
Research Memo 5

Staff Report 92-SR 59
December 1992

This material is based upon work supported by the U.S. Environmental Protection Agency, under Cooperative Agreement CR-816099-01-1.

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ABSTRACT

Atrazine is the most widely used herbicide for corn and sorghum and the most commonly encountered in surface water and groundwater. In addition to water quality problems, atrazine poses hazards through atmospheric transport, food residues, and exposure of applicators and wildlife. If atrazine use is restricted, substitute herbicides will come into wider use, increasing the likelihood of occurrence of their own sets of potentially undesirable side effects and imposing cost or efficacy penalties.

This memo updates the CEEPES evaluation of the economic and environmental costs of an atrazine and triazine ban. For an atrazine ban, we estimate a $660 million decrease in consumer and producer surplus for the entire country. Chemical concentrations in groundwater do not exceed the human health benchmarks for any herbicide with any tillage in the Corn Belt and Lake States. But concentrations in surface water do exceed the benchmarks given input substitution toward other weed control strategies. Consequently, the overall benefits of an atrazine ban are questionable.

A triazine ban decreases surplus measures by $900 million, but no average concentration of any individual herbicide would be expected to exceed human health benchmarks for surface water, except for specific soils under conventional and conservation tillage. Use of the new low-dose herbicides, nicosulfuran and primisulfuran, are predicted to increase, though uncertainty regarding their impacts on nontarget plants and pest resistance preclude long-term predictions regarding their use.

ATRAZINE AND WATER QUALITY:
AN UPDATED CEEPES ANALYSIS

Since its registration in 1959, atrazine has become the most widely used herbicide in U.S. corn and sorghum production. Current use in the midwestern United States is estimated at 52 million pounds of active ingredient (USDA 1991). Further, it accounts for nearly 12 percent of all U.S. pesticides (USEPA 1992a). Not surprisingly, atrazine is also the most widely detected pesticide in surface and groundwater. Belluck et al. (1991) note the detection rate is 10 to 20 times more frequent than the next most detected pesticide. Because of these high levels, often exceeding the Maximum Contaminant Level (MCL) of 3 parts per billion (ppb), the U.S. Environmental Protection Agency (EPA) and state agencies are reviewing policies to control or ban atrazine use.

This memo updates the Comprehensive Environmental Economic Policy Evaluation System (CEEPES) evaluation of two policies—an atrazine ban and a triazine ban on atrazine, simazine, and cyanazine. CEEPES is an integrated modeling system developed to estimate the economic and environmental consequences of alternative agricultural and environmental policies. CEEPES integrates diverse simulation models constructed around four components—policy, agricultural decisions, fate and transport, and health and ecological risk. Figure 1 illustrates the general CEEPES system. The CEEPES study region includes the Corn Belt and Lake States region, plus a portion of the Northern Plains region and five other U. S. Department of Agriculture (USDA) farm production regions. Figure 2 shows the CEEPES study region.

A major contribution of the CEEPES system is a new characterization of weed control technology resulting in the construction of more than 300 alternative weed control strategies for corn production, and more than 90 strategies for sorghum. These strategies are aimed at controlling both grass and broadleaf weeds. Each strategy includes a primary and a backup application, a set of herbicides either individually or in tank mixes, a tillage practice (no-till, reduced, and conventional), chemical application rates, an application mode (broadcast, incorporated, banded), a timing of application (early preplant, preplant incorporated, preemergent, postemergent), and windows of application and effectiveness for both the primary and the secondary strategies. In addition, production risk is incorporated by simulating the impact of uncertainty regarding the weather on dates of chemical application strategies and their effectiveness. Therefore, an atrazine ban does not simply imply a chemical-for-chemical substitution, but rather an entire set of weed control strategies that are potential substitutes. (See Bouzaher et al. 1992a,b for details of the weed control model WISH and its use in decision making under uncertainty.)

Details on the CEEPES system are available in CARD Research Memos 3 and 4. This study focuses on the updated policy evaluation given the comments and criticism offered to our preliminary CEEPES results in Research Memo 4. Some of the recommendations by weed scientists on crop injury and herbicide efficacy have not been incorporated yet because the necessary data are not yet available. The results here are aggregated over the entire study region, but they are available on a state, watershed, or county basis.

Baseline Use of Triazine Herbicides

The basic data used to calibrate the baseline herbicide in CEEPES were obtained from Resources for the Future (Gianessi and Puffer 1991). Table 1 presents the amounts of atrazine and other triazines used in the study region. Baseline atrazine use in the CEEPES system is approximately 39 million pounds active ingredient on corn and about 3.3 million pounds active ingredient on sorghum. The use of all triazines combined is about 60 million pounds active ingredient for corn and 3.3 million pounds active ingredient for sorghum.

Economic Impacts

Table 2 presents changes in the percentage of acreage of major crops. For both policy scenarios, corn acreage and corn yields decline with increases in soybean acreage and soybean yields. For the atrazine ban, corn acreage decreases by 3 percent from the baseline of 72.6 million acres and soybean acreage increases by 4.1 percent from the baseline of 44.2 million acres. Sorghum acreage increases slightly (0.7 percent and 1.9 percent), offsetting some of the production loss due to yield decreases. Table 3 shows changes in yields for major crops. Corn yield decreases by 2.8 percent for an atrazine ban and 4.1 percent for a triazine ban. Yield decreases for sorghum are much larger, at 5.7 percent and 6.8 percent for the two scenarios.

Table 4 shows that the cost of weed control per acre would increase between \$6.00 and \$8.00 for corn and less than \$1.00 for sorghum. In corn, banning atrazine requires the use of more costly weed control strategies that achieve a comparable level of control. However, in sorghum, banning atrazine leads to heavier reliance on comparably costly, less effective strategies. Under an atrazine ban, average application rates for other triazines also increased. Table 5 shows that the average application rate for cyanazine and simazine on corn increases by 249 percent and 133 percent given an atrazine ban. This implies an increase in active ingredients by 0.94 pounds and 1.34 pounds for cyanazine and simazine. Table 6 summarizes the changes in acres treated with triazines for both corn and sorghum. We separated the acres treated with weed control strategies with an atrazine rate of no more than 1.5 pound per acre rate (50.3 million acres of corn in baseline). In addition, we note a significant increase in the use of cyanazine for sorghum and simazine for corn under an atrazine ban. This can be attributed partly to our current assumption of no significant crop injury from these two triazine herbicides. This assumption will be changed as we continue to work with weed scientists from all parts of the study region.

For the Corn Belt, Figure 3 provides more detail on the changes in application rates and acreage treated for 15 different herbicides (Appendix A lists these 15 herbicides by their chemical and trade names). Of particular interest are the rate increase for both cyanazine, simazine, and other chemicals such as dicamba, bromoxynil, bentazon, pendimethalin, and 2,4-D under an atrazine ban. Chemical rates reflect average use over 50 years of weather. Because the weather does not permit application in every year, the values reported are lower than the average rate that is applied when weather permits. Figure 3 also shows the impacts of restricting the use of sulfonylureas (nicosulfuron and primisulfuron) in conjunction with an atrazine ban and a triazine ban.

Table 7 summarizes herbicide use in the study region. With an atrazine ban, total triazine use increases by 27 percent in corn and decreases by 84 percent in sorghum. In addition, we observe large increases in nontriazine and total herbicide use under both policy scenarios because the substituted weed control strategies, entail relatively high application rates.

The welfare measures associated with yield and cost impacts of an atrazine or triazine ban were estimated using the AGSIM Model developed by Robert Taylor of Auburn University (Taylor 1987, 1991, and Penson and Taylor 1992). Table 8 presents both short-term (1993-96) and long-term (2005-2008) welfare effects, including producer income, domestic consumption, foreign consumption, and government outlays.

In the short term, the average annual decreases in total economic welfare for the nation would be about $660 million under an atrazine ban and $920 million under a triazine ban. With an atrazine ban, crop producers in the Corn Belt bear a large share of the burden. Producer income from crops is reduced by $234 million in the region. For a triazine ban, some of the losses in the Corn Belt are offset by higher corn prices and the loss in producer income of $168 million is less than with the atrazine ban. Some regions would see an increase in producer income (most likely in noncorn and nonsorghum areas outside of the study region) due to an increase in certain commodity prices. Under the two restrictions, significant short-term decreases occur in government expenditures, while losses occur in net livestock income due mainly to the combined effect of a decrease in corn production and an increase in corn and sorghum prices.

Long-term impacts may not be as meaningful for the current analysis because no information was included on new, potentially more effective, weed control technologies like biological controls or new chemical substitutes. Under the current assumptions, however, total welfare impacts would be of the same magnitude as in the short run.

Table 9 shows the corresponding commodity price effects both for the short and the long run. In the short run, prices increase for corn (between 6 and 8 percent), sorghum (between 10 and 12 percent), all hay (1 percent), and hogs (1.5 percent); prices decrease for soybeans (about 1 percent), oats, wheat, and barley. In the long term, price impacts would be lessened, particularly for corn, sorghum, and soybeans.

Input Substitution Effects

The use of herbicides under the various scenarios is indicated by the distribution of corn and sorghum acres treated by different herbicide strategies (Appendix B). In the baseline, more than 65 percent of corn acres and more than 60 percent of sorghum acres are treated with a mix of strategies containing atrazine. Under an atrazine ban, more than 57 percent of corn acres, and more than 15 percent of sorghum acres would be treated with a mix of strategies containing at least one triazine herbicide. Under a triazine ban, 27 percent of corn acres and 9 percent of sorghum acres would be treated with rotary hoe and row cultivation as the main strategy. In addition, more than 50 percent of corn acres would be treated with strategies involving alachlor, metolachlor, butylate, EPTC, dicamba, and 2,4-D, and more than 90 percent of sorghum acres would be treated with strategies involving alachlor, metolachlor, dicamba, 2,4-D, and propachlor.

The use of nicosulfuron and primisulfuron as a backup strategy increases considerably when atrazine and all triazines are banned but this does not reflect potential problems with weed resistance or crop injury. Figure 3 demonstrates what would occur if nicosulfuron and primisulfuron were not allowed. In this case, other backup strategies including bentazon, bromoxynil, pendimethalin, dicamba, and 2,4-D in various combinations, would be substituted.

Appendix C summarizes shifts in rotations in the CEEPES study region. The major rotation shifts occur between continuous corn, which decrease 16 and 16.5 percent under an atrazine and triazine ban, and corn-soybean rotation, which increase by 11 and 10.4 percent under the two restriction. These changes are important because they occur for some of the most prominent rotations. By shifting to a corn-soybean rotation, savings in nitrogen fertilizer and insecticide applications are possible, which is a beneficial shift as far as water quality is concerned.

Environmental Impacts

Environmental indicators complete the picture of the welfare impacts of an atrazine and a triazine ban in the study region. Since a single average indicator of water quality across the study region would be almost meaningless, we present results indicating both *relative risk* to humans and aquatic life, and the spatial distribution of these indicators identifying the most vulnerable soils. In addition, results are separated by tillage, surface water and groundwater, and chemical.

The peak and average chemical concentration levels found in surface and groundwater are transformed into a unitless measure of risk which we call an *exposure value*, whereby pesticide-specific benchmarks for human health and aquatic habitat are used to weight the relative importance of pesticide concentrations. The term *exposure value* is used to prevent confusing such values with estimates of absolute risk. Instead, their purpose is solely for comparing policies and practices and serving as rough indicators of water quality. Using a benchmark for environmental hazards, such as drinking water Maximum Contaminant Levels (MCLs) for long-term exposures and ten-day Health Advisories for short-term exposures, we calculate the exposure for each chemical in the following way:

$$\textit{Exposure Value (hazard - weighted exposure)} = \frac{\textit{predicted concentration}}{\textit{environmental benchmark}}$$

for both peak and average long-term levels. The exposure value normalizes concentration levels, thereby allowing us to compare risks across herbicides and across policies. If the exposure value exceeds unity, the concentration exceeds the benchmark. A chemical detected in ground or surface water represents a greater risk the larger the exceedance of the benchmark. Note that more reliance should be placed on relative differences between exposure values than on absolute concentrations (USEPA 1992b).

Table 10 presents the human health exposure values for surface water from peak loadings, by chemical and tillage, under baseline use and under an atrazine ban and a triazine ban in corn production. Each line in this table represents the percent of soils with concentrations exceeding the benchmark for human toxicity. For example, the first row in Table 10 shows that atrazine concentration levels exceeded the short-term benchmark of 100 parts per billion (the drinking water maximum contamination level (MCL) for short-term exposure) in 43, 43, and 8 percent of the soils cultivated under conventional tillage, reduced till, and no-till systems. Under an atrazine ban a higher proportion of soils have chemical concentrations exceeding the benchmark in surface water under all three tillage systems (e.g., dicamba, cyanazine, simazine, and bentazon with conventional tillage; dicamba, cyanazine, and metolachlor with reduced tillage; and metolachlor and alachlor with no till). Note that for groundwater, all average concentrations are below the long-term exposure benchmarks for all soils and all tillage systems, under both an atrazine and a triazine ban. Appendix D provides the details of actual concentration and exposure levels for each chemical in the study region for the three scenarios in corn production.

Figure 4 illustrates the aquatic vegetation exposure values from corn production for the two policies. Note the majority of aquatic exposure values exceed the aquatic benchmarks, which have only been proposed as standards by EPA or have been derived according to EPA guidlines, often by more than a factor of 20.

Conclusions

Our updated CEEPES analysis leads to a number of key conclusions. With an atrazine ban we estimate a decrease in both producer and consumer surplus and an overall economic loss of $660 million for the entire country. Chemical concentrations in groundwater would not exceed EPA benchmark values for any herbicide with any tillage in any region. But by banning atrazine, producers would shift to other triazines (simazine and cyanazine) and other nontriazines (dicamba, bentazon, alachlor, metolachlor) leading to triazine and nontriazine concentrations in surface water that could significantly exceed benchmark values. Increased exposure values from substitute weed control practices sometimes exceed that before the ban, with different imports by soil and tillage type. Because the atrazine ban would result in decreased producer and consumer surplus and declines in surface water quality, there could be an overall decrease in welfare. We observe minor shifts in tillage for all crops due to the Conservation Compliance but we observe a major shift away from continuous corn to a corn-soybean rotation. Overall, the benefit of an atrazine ban is questionable.

With a triazine ban, producer and consumer surplus would decrease more than under an atrazine ban, with an overall economic loss of $900 million. But under a triazine ban no herbicide average concentrations in groundwater exceed the benchmark values. Exposure values in surface water exceeding the utility are predicted for dicamba, bentazon, alachlor, and metolachlor on a smaller proportion of soils, and only under conventional and conservation tillage. The new low-dosage herbicides, nicosulfuron and primisulfuron, are predicted to be used more widely and result in concentrations well below their human health benchmarks. However, there are major uncertainties associated with these chemicals regarding pest resistance and their hazard to aquatic and nontarget terrestrial vegetation. Overall, the costs to agricultural producers and consumers are higher with a triazine ban, but the exposure values decrease because of lower herbicide concentrations.

We are addressing several issues associated with the comprehensiveness of the analysis. First, work is under way with weed scientists in the study region to determine and incorporate yield impacts of crop injury. In addition, funding is being sought to review the weed control strategies developed for corn and sorghum and evaluate their efficacy based on local conditions in the various states. Second, we are revisiting the potential adoption of nicosulfuron and primisulfuron. Given that both chemicals are relatively new, more analysis is warranted with regard to the likelihood of other endogenous adoption. Third, there are several other policy options such as restrictions on use, technology, and timing of application that will be explored in the next few months.

Table 1. Current use of atrazine and all triazines in the study region

Crop	Chemical	RFF, 1991[a]	CEEPES[b] Baseline	NAPIAP Study[*c]
			million pounds a.i.	
Corn	Atrazine	39.9	38.9	50.6
	All Triazines	58.7	60.7	72.3
Sorghum	Atrazine	6.3	3.3	4.1
	All Triazines	6.3	3.3	4.1

[*]NAPIAP (1992) as references.

[a]Value reported is for the CEEPES study region.

[b]Value reported is for the CEEPES study region.

[c]Value reported is for 12 midwestern states.

Table 2. Percentage changes in crop acreages from baseline for chemical restrictions

	Atrazine ban	Triazine ban
	percent	
Corn	-3.0	-2.7
Sorghum	0.7	1.9
Barley	0.0	0.0
Cotton	0.0	0.0
Hay	-1.6	-0.0
Oats	1.3	2.3
Soybeans	4.1	3.9
Wheat	2.6	1.1

Table 3. Percentage changes in crop yields from baseline for chemical restrictions

	Atrazine Ban	Triazine Ban
	percent	
Corn	-2.8	-4.1
Sorghum	-5.7	-6.8
Barley	-0.00	-0.007
Cotton	0.00	0.00
Hay	2.3	.95
Oats	0.29	-0.69
Soybeans	0.20	0.24
Wheat	1.72	-0.15

Table 4. Cost change per treated acre

	Atrazine Ban	Triazine Ban
	U.S. dollars	
Corn	6.70	8.25
Sorghum	0.64	0.12

Table 5. Average application rate for triazines

	Change Atrazine Ban	Change Atrazine Ban
	(pounds, a.i.)	(percent)
Cyanazine		249
Corn	0.94	-4
Sorghum	-0.03	
Simazine		
Corn	1.34	133

Table 6. Acres treated in study region

	Current Use in CEEPES	Atrazine Ban	Triazine Ban
	mil. acres	percent change	
Atrazine (> 1.5 lb/acre)			
Corn	22.9	-100	-100
Sorghum	1.1	-100	-100
Atrazine (< 1.5 lb/acre)			
Corn	2.1	-100	-100
Sorghum	50.3	-100	-100
Cyanazine			
Corn	39.4	-46	-100
Sorghum	0.1	200	-100
Simazine			-100
Corn	5.8	>200	--
Sorghum	--	--	

Table 7. Herbicides use in study region

	Current Use in CEEPES	Atrazine Ban	Triazine Ban
	mil. lb a.i.	percent change	
Atrazine			
Corn	38.9	-100	-100
Sorghum	3.3	-100	-100
All Triazines			
Corn	60.7	27	-100
Sorghum	3.3	-84	-100
Nontriazines			
Corn	53.7	97	>200
Sorghum	9.2	31	31
All Herbicides			
Corn	112.7	60	49
Sorghum	12.5	1	-4

Table 8. Aggregate economic effects of atrazine and triazine restrictions

	Atrazine Ban		Triazine Ban	
Welfare Effects	Short-Term	Long-Term	Short-Term	Long-Term
Producer Income	-531	-312	-673	-423
Domestic Consumer Effect	-406	-421	-548	-553
Foreign Consumer Effect	-294	-134	-395	-186
Government Outlays	(-572)	(-18)	(-695)	(-21)
Total Economic Effect	-659	-849	-921	-1,141

Table 9. Price effects of atrazine and triazine restrictions—selected commodities

	Arazine Ban		Triazine Ban	
Price Effects	Short-Term	Long-Term	Short-Term	Long-Term
		percent change		
Corn	+6.4	+2.6	+8.4	+3.5
Sorghum	+10.4	+6.0	+12.2	+6.7
Soybeans	-1.2	-0.5	-1.3	-0.1
Oats	-0.8	-0.5	-0.9	-0.6
All Hay	+0.8	~0.0	+1.1	~0.0
Wheat	-0.8	-0.3	+0.4	-0.3
Barley	-0.4	+0.4	-0.7	+0.1
Hogs	+0.5	+0.5	+1.0	+1.3

Table 10. Exposure distribution in surface water for the three scenarios of soils with concentrations exceeding EPA benchmarks

Baseline	Conventional Till	Reduced Till	No-till
		percent	
Atrazine	43.10	42.87	8.08
Atrazine < 1.5	14.75	15.80	2.38
Dicamba	18.14	0.00	0.00
Cyanazine	24.91	0.92	0.00
Bentazon	2.39	45.90	0.00
Metolachlor	3.01	8.91	0.00
Alachlor	20.83	32.65	0.00
Simazine	86.95	67.66	40.12
Propachlor	6.65	38.44	.
Atrazine Medium Decay	33.65	34.13	4.72
Atrazine Slow Decay	28.31	26.06	4.26
Atrazine Fast Decay	11.73	0.01	1.13
Atrazine Ban			
Dicamba	35.08	1.21	0.00
Cyanazine	35.57	90.15	0.00
Bentazon	67.74	0.00	.
Metolachlor	0.06	26.93	12.63
Alchlor	4.70	31.61	18.28
Simazine	98.68	42.57	40.05
Triazine Ban			
Dicamba	26.66	5.60	0.00
Bentazon	51.41	84.96	.
Metolachlor	0.00	13.59	0.00
Alachlor	0.67	0.00	0.00

Note: Bromoxynil, Butylate, Glyphosate, Nicosulfuran, Pendimethalin, Primisulfuron, and 2,4-D had zero probability of exceedance in all three scenarios.

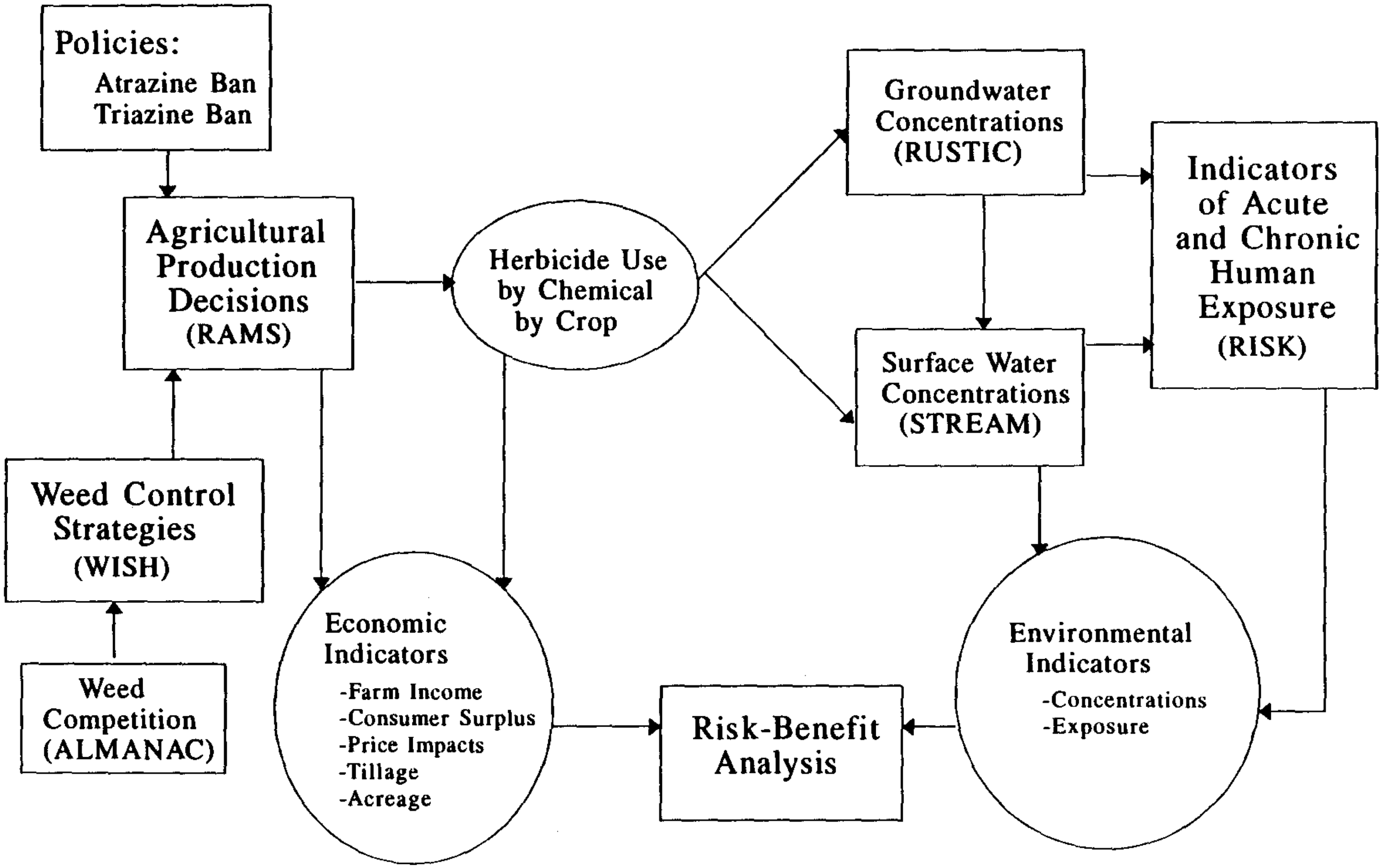


Figure 1. CEEPES configuration for atrazine

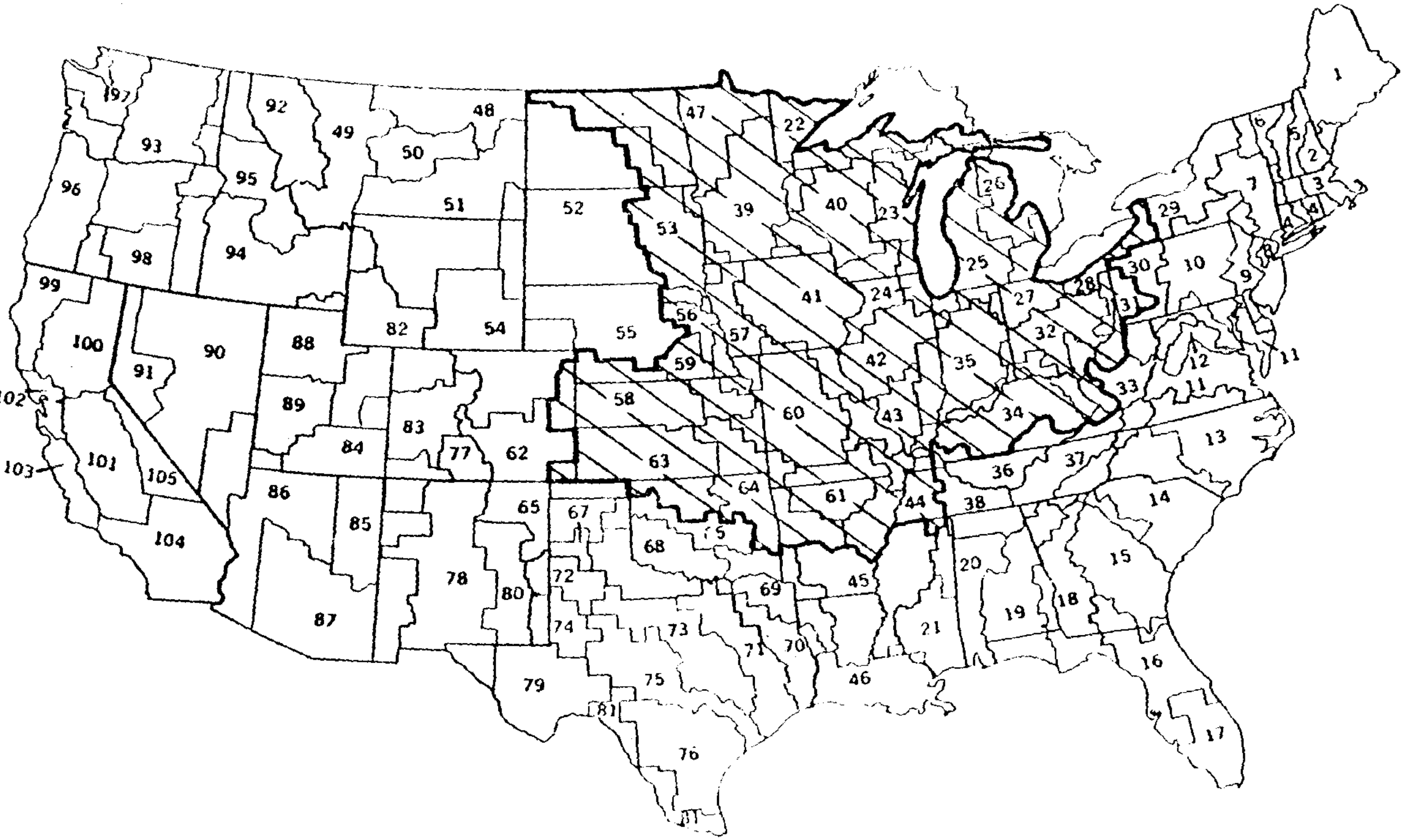
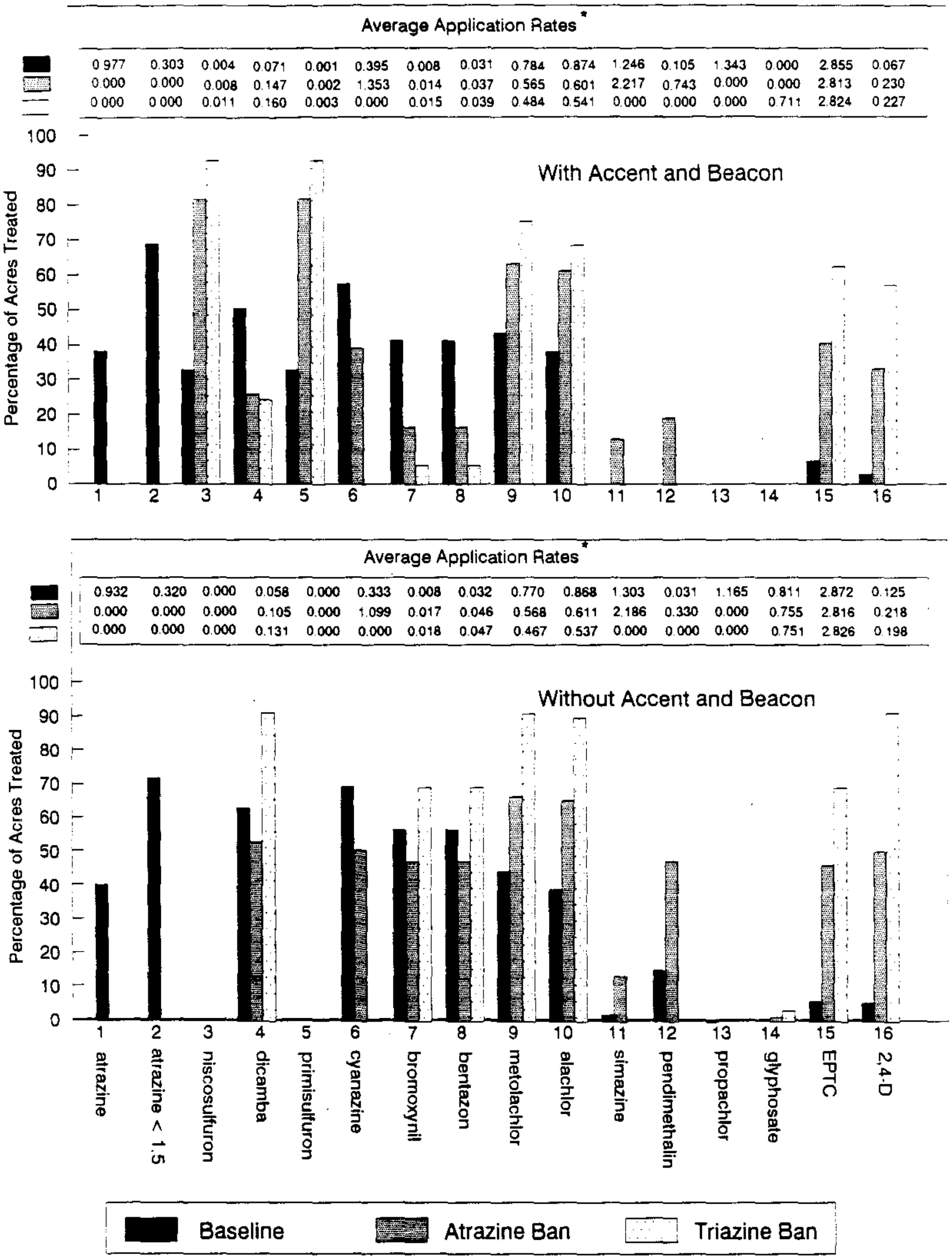


Figure 2. CEEPES study region



Average Application Rates* (With Accent and Beacon)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Baseline	0.977	0.303	0.004	0.071	0.001	0.395	0.008	0.031	0.784	0.874	1.246	0.105	1.343	0.000	2.855	0.067
Atrazine Ban	0.000	0.000	0.008	0.147	0.002	1.353	0.014	0.037	0.565	0.601	2.217	0.743	0.000	0.000	2.813	0.230
Triazine Ban	0.000	0.000	0.011	0.160	0.003	0.000	0.015	0.039	0.484	0.541	0.000	0.000	0.000	0.711	2.824	0.227

Average Application Rates* (Without Accent and Beacon)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Baseline	0.932	0.320	0.000	0.058	0.000	0.333	0.008	0.032	0.770	0.868	1.303	0.031	1.165	0.811	2.872	0.125
Atrazine Ban	0.000	0.000	0.000	0.105	0.000	1.099	0.017	0.046	0.568	0.611	2.186	0.330	0.000	0.755	2.816	0.218
Triazine Ban	0.000	0.000	0.000	0.131	0.000	0.000	0.018	0.047	0.467	0.537	0.000	0.000	0.000	0.751	2.826	0.198

Figure 3. Percentage of corn acres treated by chemicals and average application rates for the Corn Belt

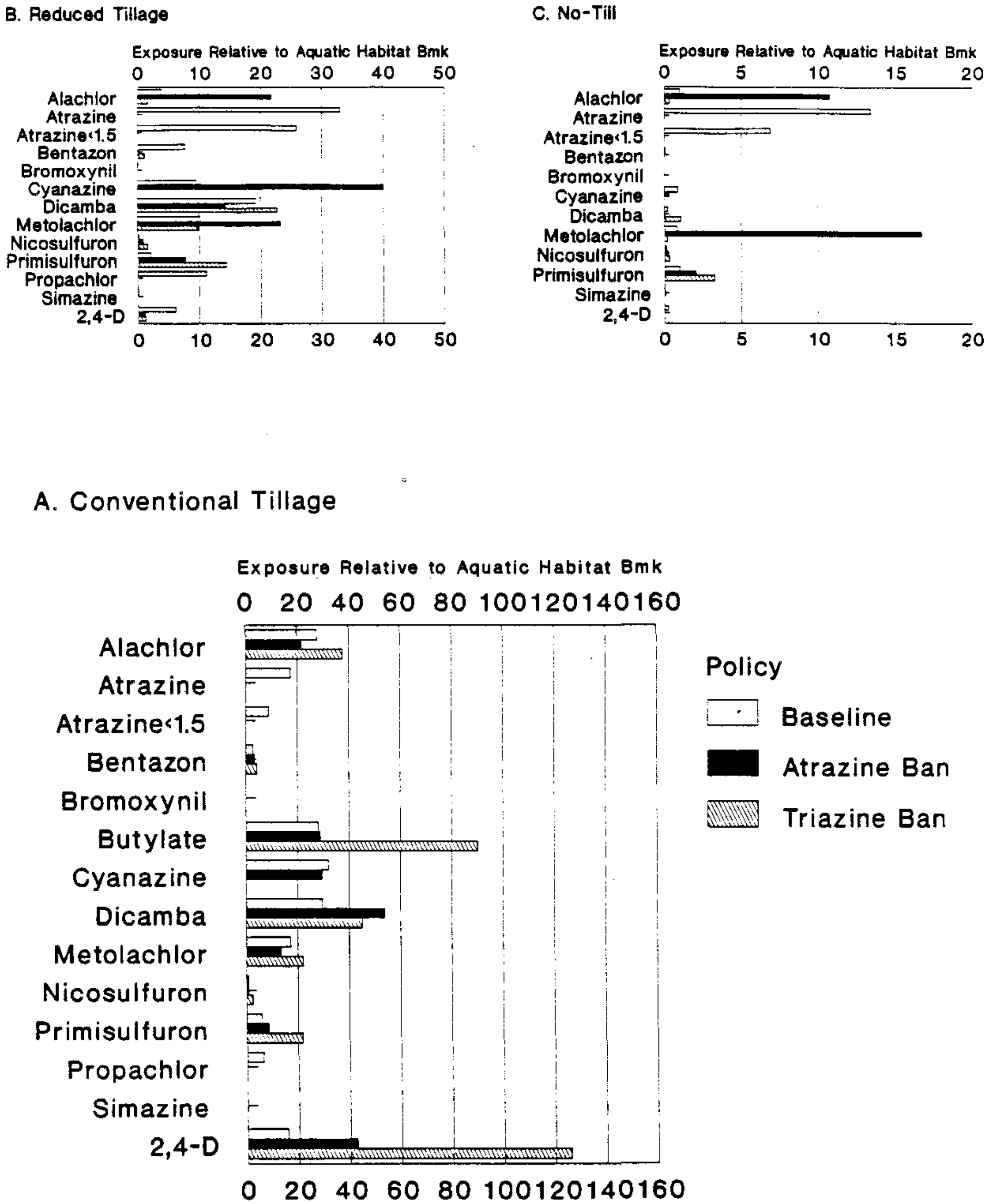


Figure 4. Aquatic risk

Note: On all these graphs the benchmark line is not shown because it is supposed to be set at the value 1.0 on the horizontal axis.

APPENDIX A. HERBICIDES INCLUDED IN CEEPES CONFIGURATION FOR ATRAZINE AND WATER QUALITY

Code	Chemical	Trade Name
Code	Alachlor	Lasson
LAS	Alchlor	Lasso
ATR	Atrazine	AAtrex
BAS	Bentazon	Basagran
BUC	Bromoxynil	Buctril
SUT	Bytylate	Sutan
BLA	Cyanazine	Bladex
BAN	Dicamba	Banvel
ERA	EPTC	Eradicane
ROU	Glyphosate	Round-up
DUA	Metolachlor	Dual
ACC	Nicosulfuran	Accent
GRA	Paraquat	Gramaxone
BEA	Primisulfuron	Beacon
PRO	Pendimenthalin	Prowl
RAM	Propachlor	Ramrod
PRI	Simazine	Princep
TFD	X2,4-D	2,4-D

APPENDIX B. SHIFTS IN WEED CONTROL STRATEGIES

Table B.1. Percentage of corn acres treated, baseline

Strategy Number	Primary Strategy	Secondary Strategy	Percent Treated
66	Atrazine[b]-Bladex preemergence	Atrazine[b]-Basagran postemergence Atrazine[b]-Banvel preemergence Atrazine[b]-Buctril preemergence	16.0
156	Atrazine[a]-Lasso preplant inc. Atrazine[a]-Dual preplant inc.	Accent preemergence Beacon preemergence	11.7
157	Atrazine[b]-Bladex preplant inc.	Atrazine[a] preemergence	9.5
158	Atrazine[2]-Bladex preplant inc.	Atrazine[b]-Basagran preemergence Atrazine[b]-Banvel preemergence Atrazine[b]-Buctril preemergence	7.6
170	Atrazine[a]-Lasso preplant inc.	Atrazine[b]-Basagran preemergence Atrazine[b]-Banvel preemergence Atrazine[a]-Buctril preemergence	5.3
69	Atrazine[b]-Bladex preemergence	2,4-D preemergence	3.9
70	Atrazine[b]-Bladex preemergence	Banvel-2,4-D preemergence	4.4
219	Sutan preplant inc & Banvel post	Accent preemergence	3.8
107	Dual-Banvel preemergence	Atrazine[b]-Basagran preemergence Atrazine[b]-Banvel preemergence Atrazine[b]-Buctril preemergence	3.6
67	Atrazine[b]-Bladex preemergence	Bladex preemergence Prowl-Bladex preemergence	3.4

[a]Atrazine applied at a rate > 1.5 lb/acre.
[b]Atrazine applied at a rate < 1.5 lb/acre.

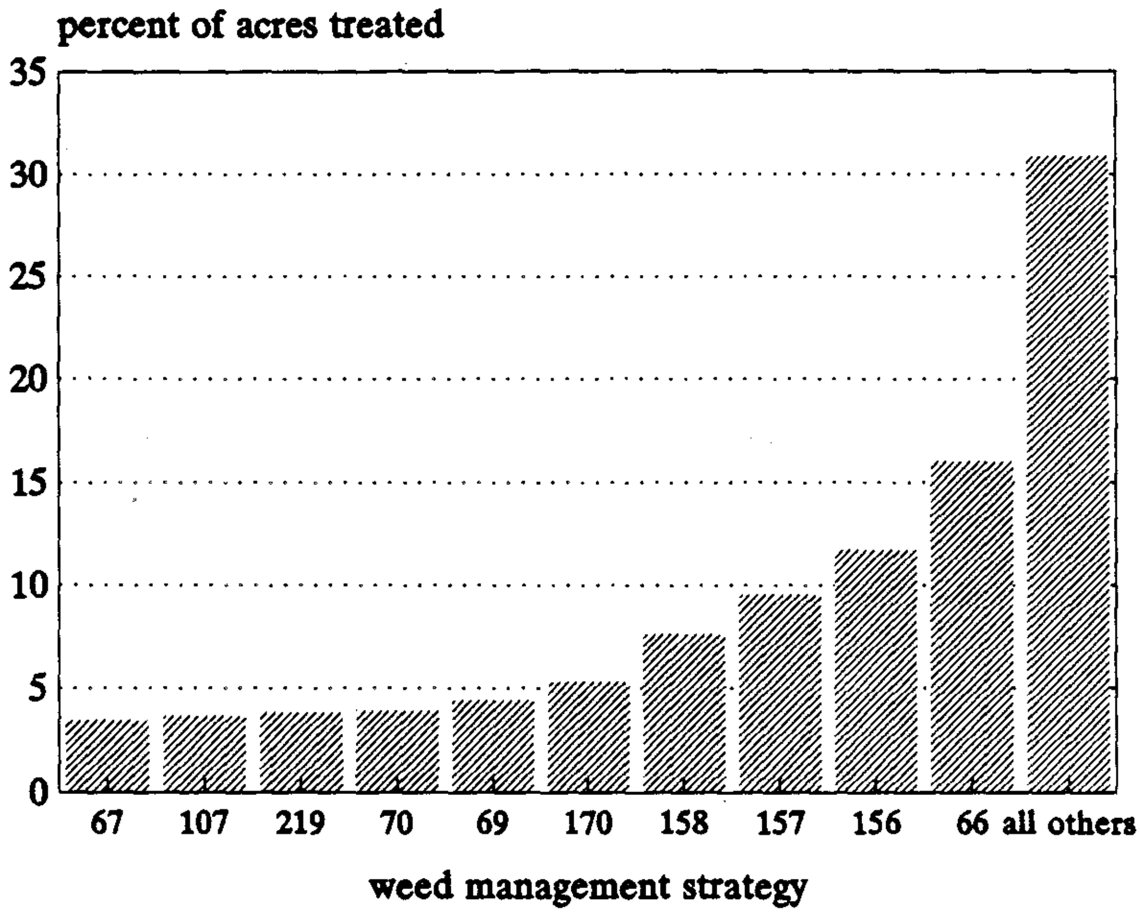


Figure B.1. Percentage of corn acres treated, baseline

Table B.2. Percentage of corn acres treated, atrazine ban

Strategy Number	Primary Strategy	Secondary Strategy	Percent Treated
185	Princep preplant incorporated	Accent postemergence Beacon postemergence	22.8
127	Bladex-Prowl preemergence	Accent postemergence Beacon postemergence	15.6
225	Sutan preplant inc. & 2,4-D postLasso preplant inc. & 2,4-D post Dual preplant inc. & 2,4-D post	Accent postemergence Beacon postemergence	11.9
99	Bladex-Lasso preemergence Bladex-Dual preemergence	Accent postemergence Beacon postemergence	11.3
223	Sutan preplant inc. & 2,4-D post Lasso preplant inc. & 2,4-D post Dual preplant inc. & Banvel post	Accent postemergence Beacon postemergence	11.1
219	Princep preplant incorporated	Banvel postemergence Buctril postemergence Basagran postemergence	3.8
183	Princep preplant incorporated	Banvel postemergence Buctril postemergence Basagran postemergence	3.8
191	Bladex-Lasso preemergence Bladex-Dual preemergence	Accent postemergence Beacon postemergence	3.4

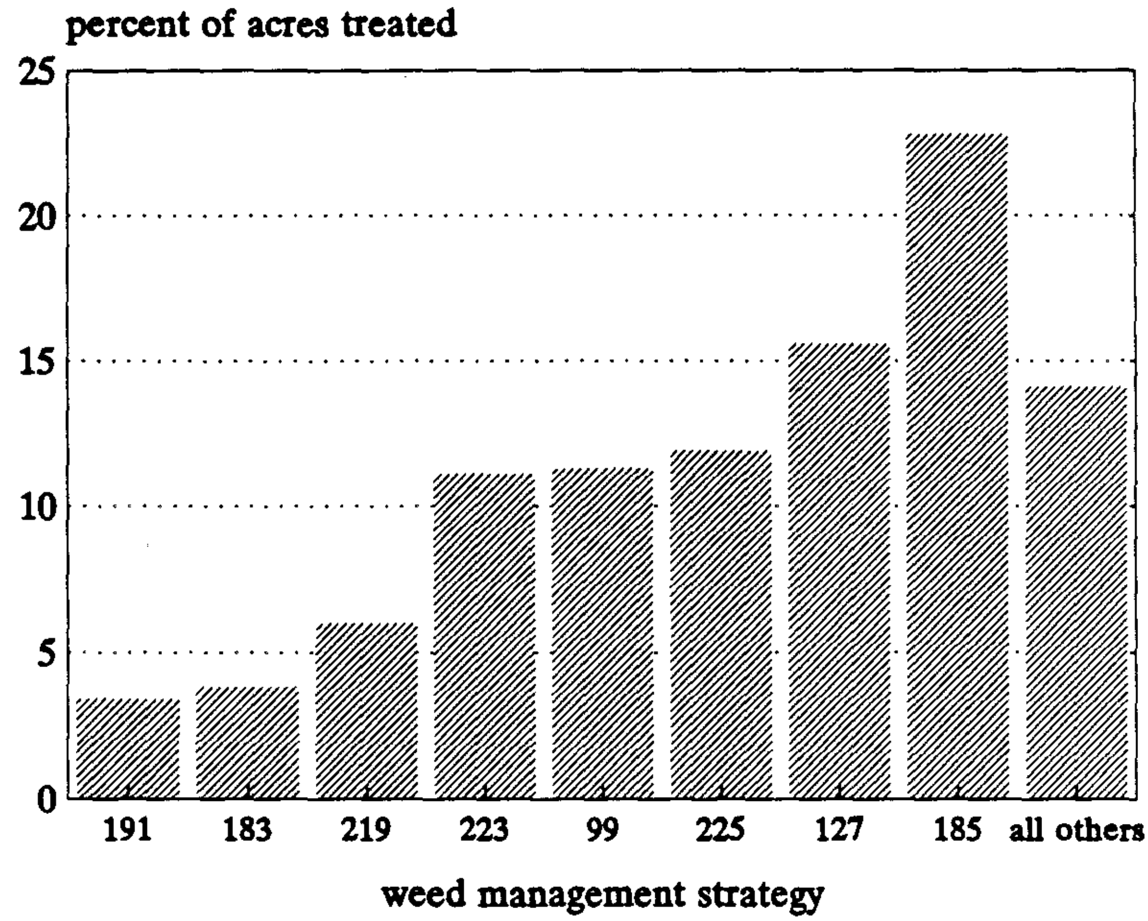


Figure B.2. Percentage of corn acres treated, atrazine ban

Table B.3. Percentage of corn acres treated, triazine ban

Strategy Number	Primary Strategy	Secondary Strategy	Percent Treated
225	Sutan preplant & 2,4-D post Lasso preplant inc. & 2,4-D post Dual preplant inc. & 2,4-D	Accent postemergence Beacon postemergence	43.9
144	Rotary hoe and row cultivation	Accent postemergence Beacon postemergence	27.0
223	Sutan preplant inc. & Banvel post Lasso preplant inc. & Banvel post Dual preplant inc. & Banvel post	Banvel postemergence Buctril postemergence Basagran postemergence	9.2
111	Dual-Banvel preemergence	Accent postemergence Beacon postemergence	4.3
219	Sutan preplant inc. & Banvel post Lasso preplant inc. & Banvel post Dual preplant inc. & Banvel post	Accent postemergence Beacon postemergence	4.3
133	Lasso preemergence & Banvel post Dual preemergence & Banvel post	Accent postemergence Beacon postemergence	3.9
52	Accent postemergence Beacon postemergence	None	3.1

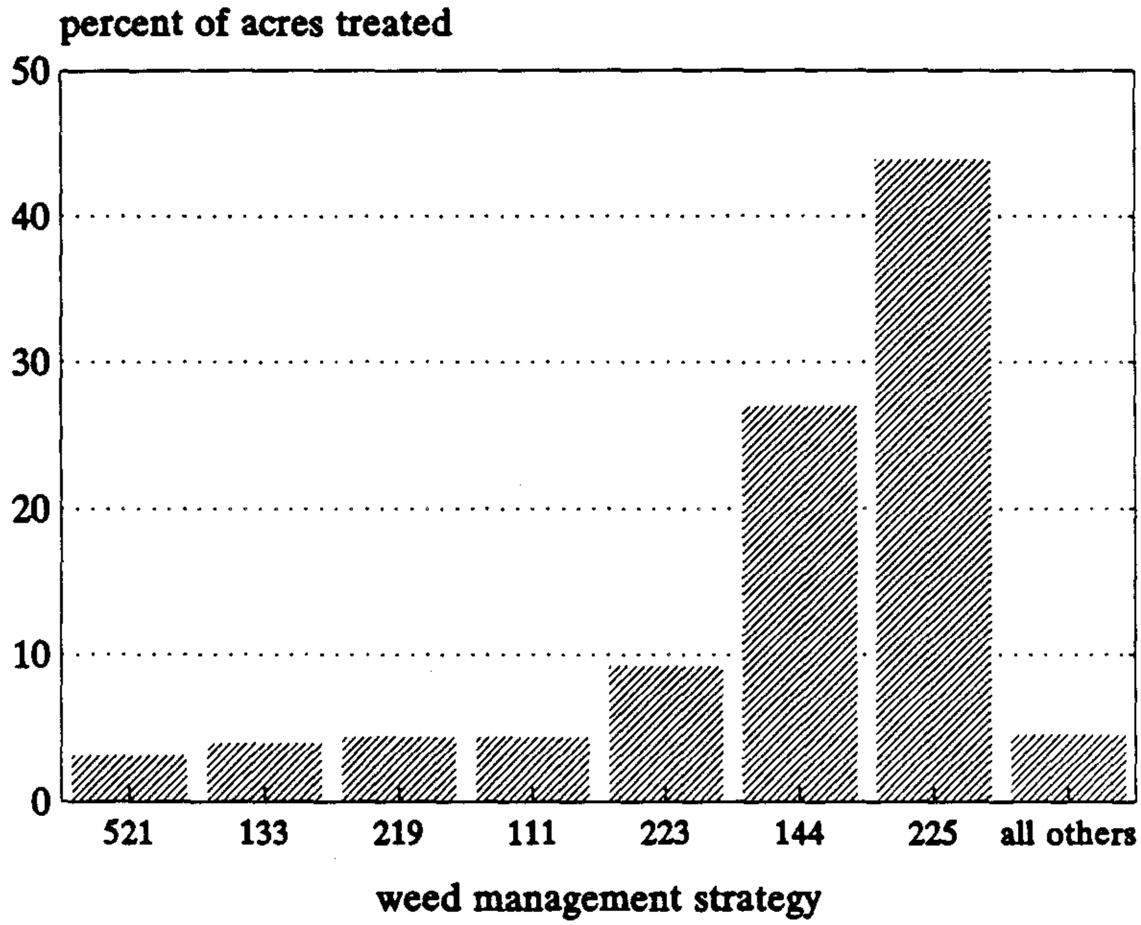


Figure B.3. Percentage of corn acreage treated, triazine ban

Table B.4. Percentage of sorghum acres treated, baseline

Strategy Number	Primary Strategy	Secondary Strategy	Percent Treated
1061	Lasso preplant inc. & Banvel post. Dual preplant inc. & Banvel post.	2,4-D postemergence Banvel 2,4-D postemergence	35.3
1059	Lasso preplant inc. & Banvel post. Dual preplant inc. & Banvel post.	Prowl-Atrazine[a] postemergence	22.0
1050	Atrazine[a] preplant incorporated	2,4-D postemergence	12.2
1042	Prowl-Atrazine[b] postemergence	None	10.3
1054	Atrazine[b]-Dual preplant inc.	Prowl-Atrazine[b] postemergence	10.2
1090	Atrazine[a] postemergence	None	5.9

[a]Atrazine applied at a rate $>$ 1.5 lb/acre.
[b]Atrazine applied at a rate $<$ 1.5 lb/acre.

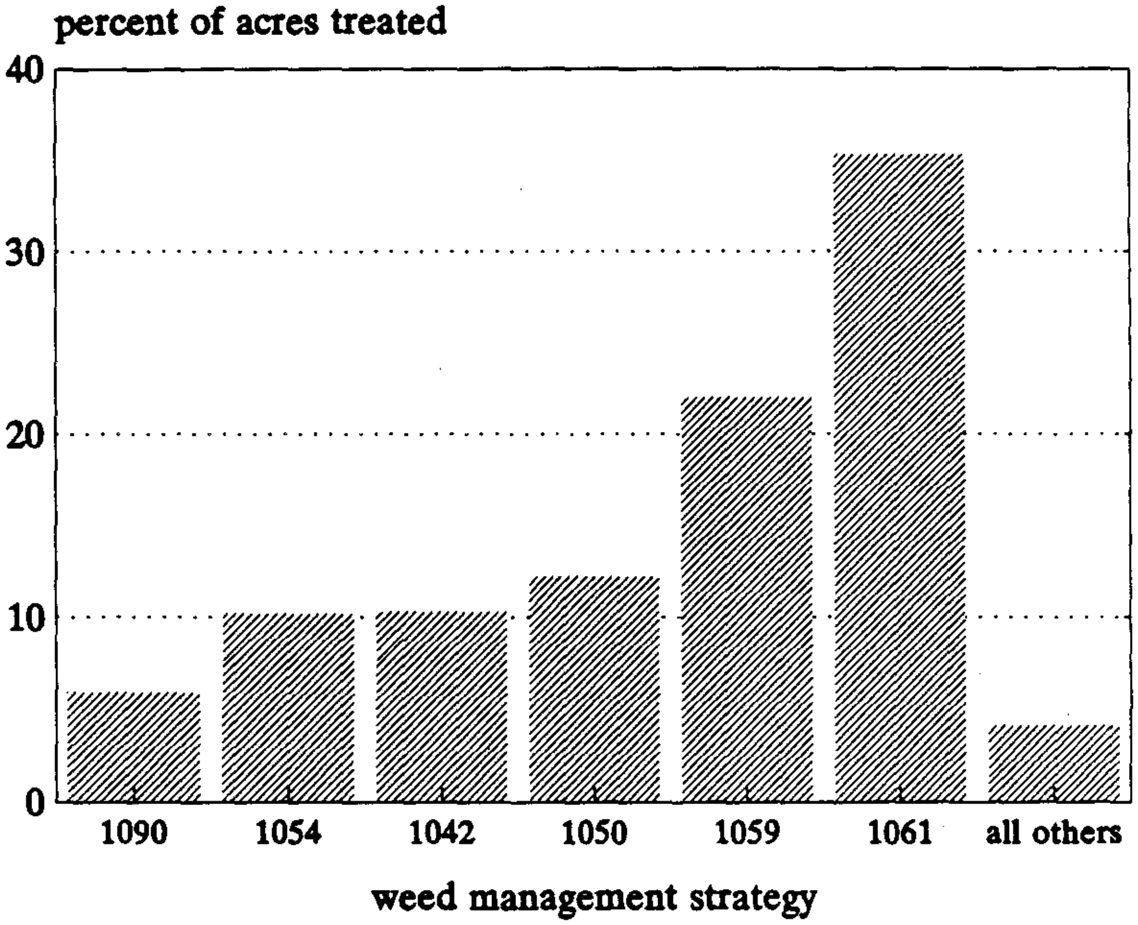


Figure B.4. Percentage of sorghum acres treated, baseline

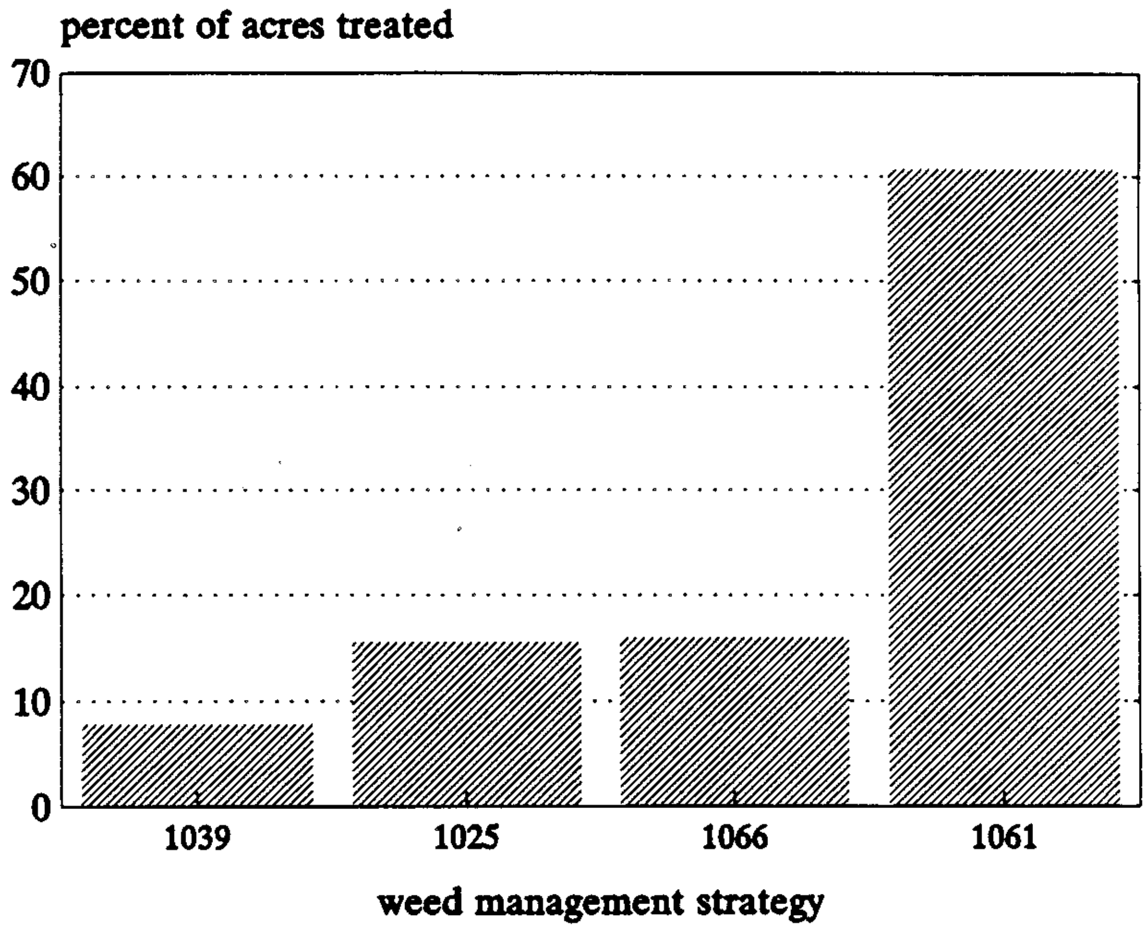


Figure B.5. Percentage of sorghum acres treated, atrazine ban

Table B.5. Percentage of sorghum acres treated, atrazine ban

Strategy Number	Primary Strategy	Secondary Strategy	Percent Treated
1061	Lasso preplant inc. & Banvel post. Dual preplant inc. & Banvel post.	2,4-D postemergence Banvel, 2,4-D postemergence	60.7
1066	Lasso preplant inc. & 2,4-D post. Dual preplant inc. & 2,4-D post.	2,4-D post-emergenc Banvel 2,44-D	15.9
1025	Bladex-Ramrod preemergence	2,4-D post emergence Banvel, 2,4-D postemergence	15.5
1039	Lasso preemergence & Banvel post. Dual preemergence & Banvel post. Ramrod preemergence & Banvel post.	2,4-D post emergence Banvel 2,4-D postemergence	7.8

Table B.6. Percentage of sorghum acres treated, triazine ban

Strategy Number	Primary Strategy	Secondary Strategy	Percent Treated
1061	Lasso preplant inc. & Banvel post. Dual preplant inc. & Banvel post.	2,4-D postemergence Banvel 2,4-D postemergence	60.2
1066	Lasso preplant inc. & 2,4-D post. Dual preplant inc. & 2,4-D post.	2,4-D postemergence Banvel 2,4-D postemergence	15.7
1039	Lasso preemergence & Banvel post. Dual preemergence & Banvel post. Ramrod preemergence & Banvel post.	2,4-D postemergence Banvel-2,4-D postemergence	15.2
1043	Rotary how and row cultivation	None	8.8

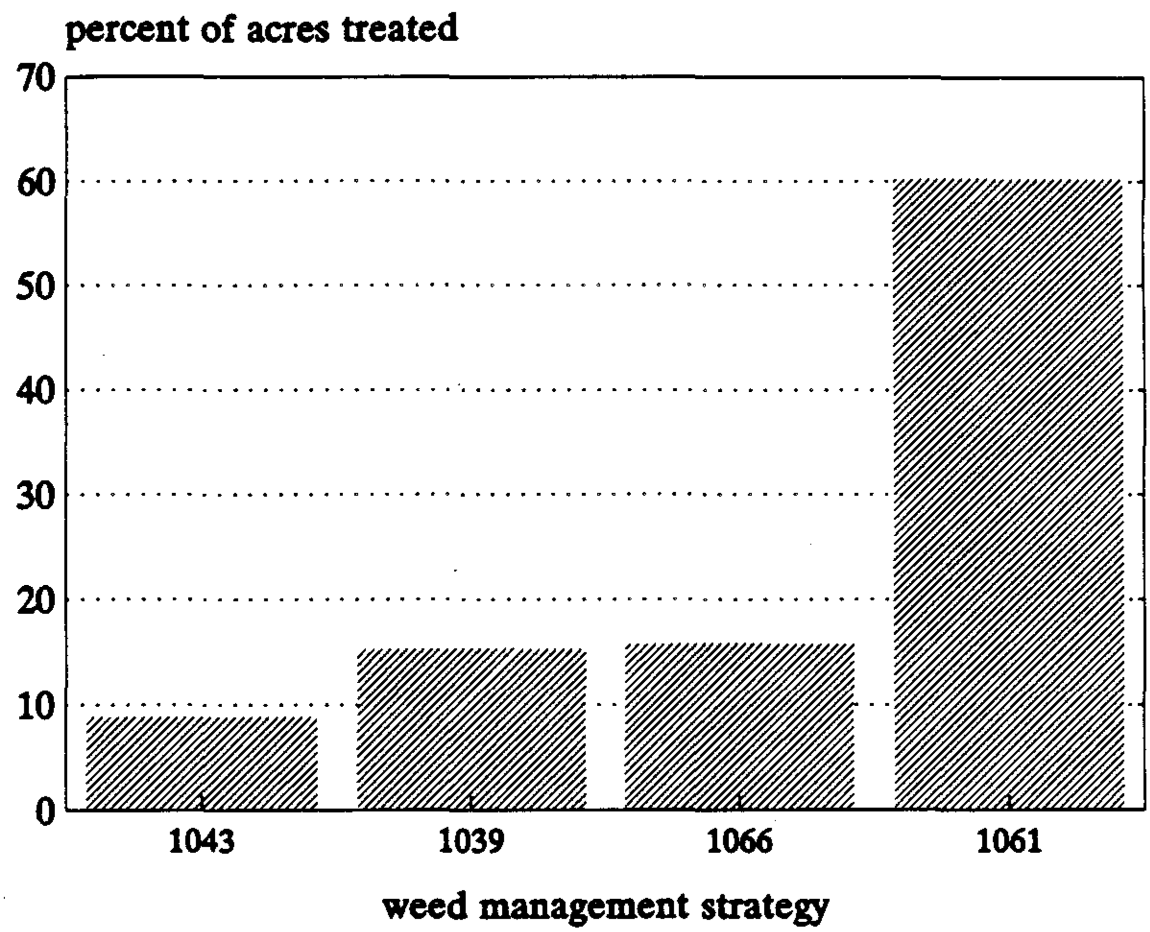


Figure B.6. Percent of sorghum acres treated, triazine ban

APPENDIX C. SHIFTS IN ROTATIONS

Change in the Distribution of Crop Rotation
(Percentage of Change from the Baseline)

ROTATION	CODE	BASELINE mil.ac	ATRZ_BAN % chg	TRIZ_BAN % chg
BAR BAR SOY	2	4.1903	0.000	0.000
BAR BAR SMF	4	0.2606	0.000	0.000
BAR CRN CRN CRN	8	0.3952	0.000	0.024
BAR CSL	11	0.0639	0.000	0.000
BAR HLH HLH CRN CRN	21	4.4649	0.000	0.000
BAR SOY	70	0.0585	1.144	1.144
BAR SUN SMF SWT	78	1.1884	0.000	0.000
BAR SWT	80	0.1244	0.000	0.000
BAR SWT SUN SWT	81	2.6112	0.000	0.000
CRN	100	18.0974	-16.010	-16.552
CRN CRN CRN OTS NLH NLH	107	0.2161	-59.545	0.000
CRN CRN CRN SWT	109	0.0027	-6.520	.
CRN CRN CRN WWT HLH	111	0.1552	111.915	199.823
CRN CRN CRN HLH HLH HLH	115	0.7133	.	.
CRN CRN OTS HLH HLH	122	0.2444	0.006	0.025
CRN CRN OTS HLH HLH HLH	123	2.3169	-79.920	-25.077
CRN CRN OTS NLH NLH	125	1.1646	-1.025	0.212
CRN CRN OTS NLH NLH NLH	126	0.2579	108.965	.
CRN CRN SOY	131	15.3956	-14.495	-12.901
CRN CRN SOY OTS HLH	132	2.6669	0.227	0.201
CRN CRN SOY SRG	136	0.5747	-24.878	-24.878
CRN CRN SOY WWT	137	0.5524	0.000	0.000
CRN CRN SOY WWT HLH	138	2.0080	-8.512	-15.344
CRN CRN WWT HLH HLH	144	1.7473	0.351	0.976
CRN CRN WWT HLH HLH HLH	145	0.6041	0.000	0.000
CRN OTS HLH HLH HLH	162	0.8612	149.892	116.890
CRN OTS NLH NLH NLH	168	0.1723	0.000	0.049
CRN OTS WWT	170	0.1019	169.026	0.000
CRN SRG	178	0.1165	7.955	7.955
CRN SOY	186	51.6816	11.116	10.409
CRN SOY CRN WWT HLH HLH	189	1.3258	0.000	0.000
CRN SOY OTS NLH NLH	196	0.5885	-3.163	42.863
CRN SOY WWT	201	12.9918	-2.874	-2.800
CRN SOY WWT HLH HLH HLH	203	3.4480	21.207	20.580
CRN SWT	210	0.2238	39.355	38.925
CRN SWT SWT	215	2.1908	27.264	33.223
CRN WWT	218	0.7467	-15.374	0.000
CRN NLH NLH	231	0.2277	0.000	0.000
CRN NLH NLH NLH	232	0.4235	0.000	0.000
CSL	235	0.5276	2.427	4.812
CSL CSL CSL SWT	239	0.4141	0.042	-98.685
CSL CSL OTS HLH	242	0.9167	-0.324	-0.324
CSL CSL OTS HLH HLH	243	1.6314	-0.154	-0.108
CSL CSL OTS HLH HLH HLH	244	1.3533	12.500	15.486
CSL CSL OTS NLH NLH	246	0.2556	6.656	5.940
CSL CSL SOY	250	0.4473	-41.129	-60.806
CSL CSL WWT NLH NLH	252	0.0053	3.367	3.367

CSL OTS	259	0.5418	-0.418	-0.373
CSL OTS HLH HLH	261	0.2843	-12.559	-11.765
CSL OTS HLH HLH HLH	262	1.6779	3.060	5.601
CSL OTS HLH HLH SWT	265	0.4283	.	.
CSL SOY CSL OTS NLH NLH	276	0.0874	-23.647	-21.877
CSL SOY HLH HLH HLH HLH	277	0.4449	0.000	0.000
CSL SWT	280	0.4112	-0.111	0.123
COT SOY	325	2.4551	0.000	0.000
HLH HLH HLH HLH SRG SOY	339	0.9416	15.14	0.00
OTS HLH HLH HLH	350	0.8094	48.51	-22.48
OTS HLH HLH HLH SRG SRG	354	0.4518	9.82	9.14
OTS NLH NLH NLH	366	2.2941	-10.40	-16.43
OTS NLH NLH NLH SOY	372	0.1380	0.00	0.00
OTS NLH NLH SSL SOY SSL	379	0.0204	5.11	6.55
OTS OTS SMF	384	0.7267	6.83	5.69
SRG	409	1.2112	0.03	-0.01
SRG SOY	415	1.4834	-15.79	-12.36
SRG SOY SOY	416	1.9871	-9.06	-9.06
SRG SOY WWT	417	0.2250	1.03	1.03
SRG SOY HLH HLH HLH HLH	419	0.2029	-0.09	-0.52
SRG WWT	424	3.3043	7.50	11.08
SRG NLH NLH	432	0.0240	1017.94	1017.94
SSL SSL WWT NLH NLH	434	0.0031	2.47	2.47
SSL WWT	439	0.0997	0.00	0.00
SOY SWT SWT	452	1.0513	0.00	0.00
SOY WWT	454	0.2606	-5.44	-5.40
SOY WWT SOY	458	0.8846	10.63	10.26
SOY WWT WWT WWT	459	1.6778	0.00	0.00
SOY NLH NLH NLH NLH	462	0.0431	-61.45	-61.45
SMF SWT	463	5.8720	-3.05	-4.20
SMF WWT	471	0.6293	.	.
SWT HLH HLH HLH	478	0.0519	0.00	781.34
WWT	490	2.8487	-12.63	-5.54
HLH HLH HLH HLH	503	18.2503	0.26	-0.09
NLH NLH NLH NLH	508	18.0575	-6.29	-3.95

APPENDIX D. GROUND AND SURFACE WATER CONCENTRATIONS AND EXPOSURE FOR 15 HERBICIDES IN THE STUDY REGION FOR BASELINE, ATRAZINE BAN, AND TRIAZINE BAN SCENARIOS IN CORN PRODUCTION

Legend:

AV12(15)	Average concentration of chemical (ppb) at 1.2 (15) meters below the surface
PK12(15):	Peak 1.2(15) meters below the surface
PKSTRM:	Peak surface water concentrations (edge of field loadings)
MCL:	Maximum Contamination Level

Ground and Surface Water Herbicide Concentrations (in parts per billion)
Policy : Baseline

CHEMICAL	AVG12	PK12	AVG15	PK15	PKSTRM
		Conv.Tillage			
Atrazine	0.24904	2.3674	0.001296	0.009379	34.9458
Atrazine<1.5	0.23983	2.7014	0.001804	0.017331	17.8924
Nicosulfuron	0.00000	0.0000	0.000000	0.000000	0.0175
Dicamba	0.00064	0.1246	0.000000	0.000002	29.4817
Primisulfuron	0.00138	0.0130	0.000006	0.000026	0.1757
Cyanazine	0.00017	0.0325	0.000000	0.000008	63.7835
Bromoxynil	0.00000	0.0000	0.000000	0.000000	0.0309
Bentazon	0.00681	0.1796	0.000010	0.000147	2.9032
Metolachlor	0.00019	0.0133	0.000000	0.000009	17.1911
Alachlor	0.00009	0.0147	0.000000	0.000001	27.7008
Simazine	0.23551	1.8963	0.002580	0.019724	34.7559
Pendimethalin	0.00000	0.0000	0.000000	0.000000	0.0000
Propachlor	0.00001	0.0011	0.000000	0.000000	6.3120
Butylate	0.00983	2.7832	0.000000	0.000004	28.1301
2,4-D	0.00003	0.0145	0.000000	0.000000	15.7291
Atrz-Med-Decay	0.47923	4.3875	0.002944	0.022901	59.0422
Atrz-Slow-Decay	2.83069	10.8769	0.056920	0.099106	52.0976
Atrz-Fast-Decay	0.00009	0.0085	0.000000	0.000000	25.4502
		Reduced Tillage			
Atrazine	0.60158	7.0364	0.004093	0.02418	65.918
Atrazine<1.5	0.52893	5.3189	0.003573	0.02304	51.643
Nicosulfuron	0.00000	0.0000	0.000000	0.00000	0.006
Dicamba	0.00064	0.1688	0.000000	0.00001	19.254
Primisulfuron	0.00090	0.0094	0.000003	0.00002	0.062
Cyanazine	0.00005	0.0093	0.000000	0.00000	19.215
Bromoxynil	0.00000	0.0000	0.000000	0.00000	0.072
Bentazon	0.02229	0.5347	0.000028	0.00030	7.704
Metolachlor	0.00004	0.0031	0.000000	0.00000	10.160
Alachlor	0.00001	0.0022	0.000000	0.00000	3.891
Simazine	0.22449	1.7034	0.002092	0.01350	22.949
Pendimethalin	0.00000	0.0000	0.000000	.	0.000
Propachlor	0.00001	0.0037	0.000000	0.00000	11.067
2,4-D	0.00004	0.0226	0.000000	0.00000	6.071
Atrz-Med-Decay	1.10987	10.8803	0.007317	0.04236	133.502
Atrz-Slow-Decay	6.32963	26.2752	0.099055	0.14595	117.672
Atrz-Fast-Decay	0.00054	0.0515	0.000000	0.00000	23.729
		No-Till			
Atrazine	0.25210	2.73901	0.002933	0.023260	26.8218
Atrazine<1.5	0.10878	0.98029	0.000925	0.005138	13.7617
Nicosulfuron	0.00000	0.00000	0.000000	0.000000	0.0029
Dicamba	0.00001	0.00359	0.000000	0.000000	0.2557
Primisulfuron	0.00088	0.00857	0.000006	0.000024	0.0300
Cyanazine	0.00000	0.00055	0.000000	0.000000	1.7765
Bromoxynil	0.00000	0.00000	0.000000	0.000000	0.0006
Bentazon	0.00047	0.00986	0.000001	0.000008	0.0634
Metolachlor	0.00002	0.00125	0.000000	0.000001	0.8591
Alachlor	0.00000	0.00057	0.000000	0.000000	0.9827
Simazine	0.18579	1.11248	0.003074	0.012677	15.2363
Pendimethalin	0.00000	0.00000	0.000000	0.000000	0.0000
2,4-D	0.00000	0.00087	0.000000	0.000000	0.2505
Atrz-Med-Decay	0.35380	3.23373	0.003656	0.024598	45.8989
Atrz-Slow-Decay	2.05537	7.92776	0.062238	0.093926	40.4743
Atrz-Fast-Decay	0.00013	0.01297	0.000000	0.000000	8.0125

Ground and Surface Water Herbicide Concentrations (in parts per billion)
Policy: Atrazine Ban

CHEMICAL	AVG12	PK12	AVG15	PK15	PKSTRM
		Conv.Tillage			
Nicosulfuron	0.00000	0.0000	0.000000	0.000000	0.027
Dicamba	0.00114	0.2313	0.000000	0.000003	53.845
Primisulfuron	0.00265	0.0281	0.000014	0.000061	0.256
Cyanazine	0.00017	0.0343	0.000000	0.000009	58.733
Bromoxynil	0.00000	0.0000	0.000000	0.000000	0.044
Bentazon	0.00592	0.1301	0.000008	0.000090	3.228
Metolachlor	0.00029	0.0220	0.000000	0.000033	13.308
Alachlor	0.00015	0.0244	0.000000	0.000010	21.492
Simazine	1.37028	10.9284	0.013849	0.090643	134.997
Butylate	0.01052	3.0583	0.000000	0.000004	28.729
2,4-D	0.00009	0.0365	0.000000	0.000000	42.603
		Reduced Tillage			
Nicosulfuron	0.000000	0.00000	.00000000	.0000000	0.0235
Dicamba	0.000418	0.10324	.00000000	.0000012	14.2105
Primisulfuron	0.002906	0.03080	.00001459	.0000550	0.2298
Cyanazine	0.000078	0.01260	.00000000	.0000006	79.8721
Bromoxynil	0.000000	0.00000	.00000000	.0000000	0.0026
Bentazon	0.000016	0.00097	.00000000	.0000000	0.1847
Metolachlor	0.000128	0.00887	.00000003	.0000044	23.2487
Alachlor	0.000040	0.00631	.00000000	.0000004	21.6838
Simazine	0.018520	0.13033	.00029247	.0018712	2.3393
Pendimethalin	0.000000	0.00000	.00000000	.	0.0000
2,4-D	0.000003	0.00145	.00000000	.0000000	1.0366
		No-Till			
Nicosulfuron	0.000000	0.00000	.0000000	.0000000	0.0062
Dicamba	0.000001	0.00022	.0000000	.0000000	0.0260
Primisulfuron	0.001561	0.01534	.0000131	.0000478	0.0610
Cyanazine	0.000001	0.00012	.0000000	.0000000	0.5952
Metolachlor	0.000305	0.02146	.0000006	.0000456	16.6854
Alachlor	0.000058	0.00875	.0000000	.0000041	10.7396
Simazine	0.084350	0.53965	.0010061	.0062077	26.8990
Pendimethalin	0.000000	0.00000	.0000000	.0000000	0.0000
Glyphosate	0.000000	0.00000	.0000000	.0000000	0.0000

Ground and Surface Water Herbicide Concentrations (in parts per billion)
Policy: Triazine Ban

CHEMICAL	AVG12	PK12	AVG15	PK15	PKSTRM
		Conv.Tillage			
Nicosulfuron	0.000000	0.00000	.000000000	.00000000	0.072
Dicamba	0.000849	0.17073	.000000007	.00000203	45.053
Primisulfuron	0.006444	0.07271	.000034789	.00014400	0.655
Bromoxynil	0.000000	0.00000	.000000000	.00000000	0.059
Bentazon	0.007219	0.19859	.000004937	.00011283	4.362
Metolachlor	0.000368	0.02846	.000000535	.00003907	22.064
Alachlor	0.000187	0.03158	.000000074	.00001069	37.631
Butylate	0.028833	9.79993	.000000637	.00015354	90.059
2,4-D	0.000347	0.17729	.000000002	.00000092	126.123
		Reduced Tillage			
Nicosulfuron	.0000000	0.00000	.000000000	.00000000	0.0451
Dicamba	.0007748	0.16183	.000000004	.00000238	22.7040
Primisulfuron	.0060336	0.06930	.000030323	.00010681	0.4287
Bromoxynil	.0000000	0.00000	.000000000	.00000000	0.0162
Bentazon	.0000983	0.00590	.000000003	.00000014	1.1282
Metolachlor	.0000694	0.00407	.000000021	.00000247	9.7194
Alachlor	.0000085	0.00099	.000000000	.00000009	1.6802
2,4-D	.0000035	0.00171	.000000000	.00000000	1.1657
		No-Till			
Nicosulfuron	.0000000	0.000000	.000000000	.000000001	0.01009
Dicamba	.0000362	0.009751	.000000000	.000000117	1.08519
Primisulfuron	.0028049	0.028281	.000022393	.000083589	0.09718
Metolachlor	.0000049	0.000403	.000000001	.000000288	0.18317
Alachlor	.0000026	0.000483	.000000000	.000000044	0.33859
Glyphosate	.0000000	0.000000	.000000000	.000000000	0.00000

Ground and Surface Water Exposures (relative to EPAs MCL)
Policy: Baseline

CHEMICAL	AVG12	PK12	AVG15	PK15	PKSTRM
	Conv.Tillage				
Atrazine	0.08301	0.02367	0.000432	.00009379	0.34946
Atrazine<1.5	0.07994	0.02701	0.000601	.00017331	0.17892
Nicosulfuron	0.00000	0.00000	0.000000	.00000000	0.00040
Dicamba	0.00007	0.00042	0.000000	.00000001	0.09827
Primisulfuron	0.00001	0.00006	0.000000	.00000013	0.00084
Cyanazine	0.00002	0.00033	0.000000	.00000008	0.63784
Bromoxynil	0.00000	0.00000	0.000000	.00000000	0.00004
Bentazon	0.00034	0.00719	0.000000	.00000589	0.11613
Metolachlor	0.00000	0.00013	0.000000	.00000009	0.17191
Alachlor	0.00005	0.00015	0.000000	.00000001	0.27701
Simazine	0.00673	0.03793	0.000074	.00039448	0.69512
Pendimethalin	0.00000	0.00000	0.000000	.00000000	0.00000
Propachlor	0.00000	0.00000	0.000000	.00000000	0.01803
Butylate	0.00020	0.00116	0.000000	.00000000	0.01172
2,4-D	0.00000	0.00001	0.000000	.00000000	0.01430
Atrz-Med-Decay	0.15974	0.04388	0.000981	.00022901	0.59042
Atrz-Slow-Decay	0.94356	0.10877	0.018973	.00099106	0.52098
Atrz-Fast-Decay	0.00003	0.00008	0.000000	.00000000	0.25450
	Reduced Tillage				
Atrazine	0.20053	0.07036	0.001364	.0002418	0.65918
Atrazine<1.5	0.17631	0.05319	0.001191	.0002304	0.51643
Nicosulfuron	0.00000	0.00000	0.000000	.0000000	0.00015
Dicamba	0.00007	0.00056	0.000000	.0000000	0.06418
Primisulfuron	0.00000	0.00004	0.000000	.0000001	0.00030
Cyanazine	0.00001	0.00009	0.000000	.0000000	0.19215
Bromoxynil	0.00000	0.00000	0.000000	.0000000	0.00010
Bentazon	0.00111	0.02139	0.000001	.0000121	0.30815
Metolachlor	0.00000	0.00003	0.000000	.0000000	0.10160
Alachlor	0.00001	0.00002	0.000000	.0000000	0.03891
Simazine	0.00641	0.03407	0.000060	.0002699	0.45898
Pendimethalin	0.00000	0.00000	0.000000	.	0.00000
Propachlor	0.00000	0.00001	0.000000	.0000000	0.03162
2,4-D	0.00000	0.00002	0.000000	.0000000	0.00552
Atrz-Med-Decay	0.36996	0.10880	0.002439	.0004236	1.33502
Atrz-Slow-Decay	2.10988	0.26275	0.033018	.0014595	1.17672
Atrz-Fast-Decay	0.00018	0.00052	0.000000	.0000000	0.23729
	No-Till				
Atrazine	0.08403	0.027390	0.000978	.00023260	0.26822
Atrazine<1.5	0.03626	0.009803	0.000308	.00005138	0.13762
Nicosulfuron	0.00000	0.000000	0.000000	.00000000	0.00007
Dicamba	0.00000	0.000012	0.000000	.00000000	0.00085
Primisulfuron	0.00000	0.000041	0.000000	.00000011	0.00014
Cyanazine	0.00000	0.000006	0.000000	.00000000	0.01777
Bromoxynil	0.00000	0.000000	0.000000	.00000000	0.00000
Bentazon	0.00002	0.000394	0.000000	.00000031	0.00254
Metolachlor	0.00000	0.000013	0.000000	.00000001	0.00859
Alachlor	0.00000	0.000006	0.000000	.00000000	0.00983
Simazine	0.00531	0.022250	0.000088	.00025355	0.30473
Pendimethalin	0.00000	0.000000	0.000000	.00000000	0.00000
2,4-D	0.00000	0.000001	0.000000	.00000000	0.00023
Atrz-Med-Decay	0.11793	0.032337	0.001219	.00024598	0.45899
Atrz-Slow-Decay	0.68512	0.079278	0.020746	.00093926	0.40474
Atrz-Fast-Decay	0.00004	0.000130	0.000000	.00000000	0.08013

Ground and Surface Water Exposures (relative to EPAs MCL)
Policy: Atrazine Ban

CHEMICAL	AVG12	PK12	AVG15	PK15	PKSTRM
		Conv.Tillage			
Nicosulfuron	0.000000	0.00000	.00000000	.0000000	0.00061
Dicamba	0.000127	0.00077	.00000000	.0000000	0.17948
Primisulfuron	0.000013	0.00013	.00000006	.0000003	0.00122
Cyanazine	0.000019	0.00034	.00000001	.0000001	0.58733
Bromoxynil	0.000000	0.00000	.00000000	.0000000	0.00006
Bentazon	0.000296	0.00520	.00000038	.0000036	0.12914
Metolachlor	0.000003	0.00022	.00000000	.0000003	0.13308
Alachlor	0.000073	0.00024	.00000003	.0000001	0.21492
Simazine	0.039151	0.21857	.00039569	.0018129	2.69993
Butylate	0.000210	0.00127	.00000000	.0000000	0.01197
2,4-D	0.000001	0.00003	.00000000	.0000000	0.03873
		Reduced Tillage			
Nicosulfuron	.00000000	.0000000	.0000000000	.000000000	0.00053
Dicamba	.00004650	.0003441	.0000000005	.000000004	0.04737
Primisulfuron	.00001384	.0001466	.0000000695	.000000262	0.00109
Cyanazine	.00000868	.0001260	.0000000002	.000000006	0.79872
Bromoxynil	.00000000	.0000000	.0000000000	.000000000	0.00000
Bentazon	.00000080	.0000386	.0000000000	.000000001	0.00739
Metolachlor	.00000128	.0000887	.0000000003	.000000044	0.23249
Alachlor	.00002006	.0000631	.0000000006	.000000004	0.21684
Simazine	.00052914	.0026066	.0000083563	.000037424	0.04679
Pendimethalin	.00000000	.0000000	.0000000000	.	0.00000
2,4-D	.00000004	.0000013	.0000000000	.000000000	0.00094
		No-Till			
Nicosulfuron	.0000000	0.000000	.000000000	.00000000	0.00014
Dicamba	.0000001	0.000001	.000000000	.00000000	0.00009
Primisulfuron	.0000074	0.000073	.000000062	.00000023	0.00029
Cyanazine	.0000001	0.000001	.000000000	.00000000	0.00595
Metolachlor	.0000031	0.000215	.000000006	.00000046	0.16685
Alachlor	.0000289	0.000088	.000000014	.00000004	0.10740
Simazine	.0024100	0.010793	.000028745	.00012415	0.53798
Pendimethalin	.0000000	0.000000	.000000000	.00000000	0.00000
Glyphosate	.0000000	0.000000	.000000000	.00000000	0.00000

Ground and Surface Water Exposures (relative to EPAs MCL)
Policy: Triazine Ban

CHEMICAL	AVG12	PK12	AVG15	PK15	PKSTRM
	Conv.Tillage				
Nicosulfuron	.00000000	.0000000	.00000000001	.0000000000	0.00164
Dicamba	.00009436	.0005691	.00000000072	.0000000068	0.15018
Primisulfuron	.00003069	.0003462	.00000016566	.0000006857	0.00312
Bromoxynil	.00000000	.0000000	.00000000000	.0000000000	0.00008
Bentazon	.00036095	.0079435	.00000024685	.0000045131	0.17447
Metolachlor	.00000368	.0002846	.00000000535	.0000003907	0.22064
Alachlor	.00009343	.0003158	.00000003709	.0000001069	0.37631
Butylate	.00057665	.0040833	.00000001273	.0000000640	0.03752
2,4-D	.00000496	.0001612	.00000000003	.0000000008	0.11466
	Reduced Tillage				
Nicosulfuron	.000000000	.00000001	.00000000001	.00000000003	0.001025
Dicamba	.000086086	.00053943	.00000000039	.00000000794	0.075680
Primisulfuron	.000028732	.00033002	.00000014440	.00000050861	0.002041
Bromoxynil	.000000000	.00000000	.00000000000	.00000000000	0.000023
Bentazon	.000004914	.00023589	.00000000015	.00000000545	0.045130
Metolachlor	.000000694	.00004068	.00000000021	.00000002475	0.097194
Alachlor	.000004230	.00000994	.00000000015	.00000000095	0.016802
2,4-D	.000000050	.00000156	.00000000000	.00000000000	0.001060
	No-Till				
Nicosulfuron	.000000000	.00000001	.00000000000	.00000000003	.0002293
Dicamba	.000004024	.00003250	.00000000002	.00000000039	.0036173
Primisulfuron	.000013357	.00013467	.00000010663	.00000039804	.0004628
Metolachlor	.000000049	.00000403	.00000000001	.00000000288	.0018317
Alachlor	.000001300	.00000483	.00000000003	.00000000044	.0033859
Glyphosate	.000000000	.00000000	.00000000000	.00000000000	.0000000

Ground and Surface Water Exposures (relative to EPAs MCL)
Policy: Triazine Ban

CHEMICAL	AVG12	PK12	AVG15	PK15	PKSTRM
		Conv.Tillage			
Nicosulfuron	.00000000	.0000000	.00000000001	.0000000000	0.00164
Dicamba	.00009436	.0005691	.00000000072	.0000000068	0.15018
Primisulfuron	.00003069	.0003462	.00000016566	.0000006857	0.00312
Bromoxynil	.00000000	.0000000	.00000000000	.0000000000	0.00008
Bentazon	.00036095	.0079435	.00000024685	.0000045131	0.17447
Metolachlor	.00000368	.0002846	.00000000535	.0000003907	0.22064
Alachlor	.00009343	.0003158	.00000003709	.0000001069	0.37631
Butylate	.00057665	.0040833	.00000001273	.0000000640	0.03752
2,4-D	.00000496	.0001612	.00000000003	.0000000008	0.11466
		Reduced Tillage			
Nicosulfuron	.000000000	.00000001	.00000000001	.00000000003	0.001025
Dicamba	.000086086	.00053943	.00000000039	.00000000794	0.075680
Primisulfuron	.000028732	.00033002	.00000014440	.00000050861	0.002041
Bromoxynil	.000000000	.00000000	.00000000000	.00000000000	0.000023
Bentazon	.000004914	.00023589	.00000000015	.00000000545	0.045130
Metolachlor	.000000694	.00004068	.00000000021	.00000002475	0.097194
Alachlor	.000004230	.00000994	.00000000015	.00000000095	0.016802
2,4-D	.000000050	.00000156	.00000000000	.00000000000	0.001060
		No-Till			
Nicosulfuron	.000000000	.00000001	.00000000000	.00000000003	.0002293
Dicamba	.000004024	.00003250	.00000000002	.00000000039	.0036173
Primisulfuron	.000013357	.00013467	.00000010663	.00000039804	.0004628
Metolachlor	.000000049	.00000403	.00000000001	.00000000288	.0018317
Alachlor	.000001300	.00000483	.00000000003	.00000000044	.0033859
Glyphosate	.000000000	.00000000	.00000000000	.00000000000	.0000000

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