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EXECUTIVE SUMMARY

Atrazine has been detected in groundwater in parts of North America. Despite a downward trend in atrazine use over the past decade (WASS, 1991), Wisconsin has not escaped the environmental risk associated with this herbicide. Three factors contribute to the scope of the problem: 1) the long-standing popularity of atrazine as an inexpensive, reliable herbicide, 2) the amount of corn planted, and 3) atrazine's leaching characteristics. Data from a series of Wisconsin groundwater quality surveys, representing a wide range of soil and hydrologic conditions, has led to the conclusion that atrazine has the potential to be present in all areas of the state where it is used (DATCP, 1992). Based on earlier experience with aldicarb (Gustafson, 1991) and a desire to create a structured approach for managing anticipated threats to groundwater, Wisconsin adopted a Groundwater Law in 1983 (Chapter 160, Wisc. stats). This law along with the subsequent adoption of a set of human-health-based contaminant standards (NR 140, Wis. Admin. Code) required the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) to address the emerging patterns of atrazine detections (Belluck, 1988). DATCP's response, as required under law, was the promulgation of Ag 30, the Atrazine Rule, the nation's most restrictive atrazine policy.

In a context of broad uncertainty regarding the relative contributions to groundwater atrazine detections from non-point sources, point sources, and quasi-point sources (Hallberg, 1986; Fawcett, 1990) as well as "recent" versus "historic" atrazine, DATCP elected to restrict field application of atrazine beyond the federal standards beginning in the 1991 growing season. The restrictions represent a three-tiered structure: a statewide set of rules; a more restrictive set of rate restrictions applied to a series of Atrazine Management Areas (AMAs) and the designation of a series of Atrazine Prohibition Areas (APAs) in which atrazine use is not allowed under any circumstances. During the 1992 growing season, the area designated as AMA totaled approximately 290,000 ha in five counties, and 11 distinct areas totalling approximately 9700 ha were designated as APAs.

This tiered structure is a result of the differential responses available to DATCP to address a groundwater problem under state law. According to the Groundwater Law, where detections exceed the atrazine Preventive Action Limit (PAL) of 0.35 ppb, DATCP must take steps to prevent further degradation. Because of the diffuse pattern of detections, the decision was made to create statewide restrictions. In those areas where the density and intensity of detections warranted a stronger response, AMA designation was made. When the detections are found to exceed 3.0 ppb, the Enforcement Standard (ES), DATCP is directed to prohibit use, hence the APAs. It should be noted that despite this formulaic representation of the atrazine rule-making process, the uncertainty of groundwater contamination processes in the context of the Groundwater Law has required interpretation and compromise by DATCP and other participant groups.

The rules limit field application of atrazine on the basis of soil surface texture, last year's usage, and AMA designation (See Table 1). Under the rules, atrazine applications are limited to the period between April 15th and July 31st; all handlers and applicators must be certified by the state; non-crop uses are prohibited; irrigation restrictions apply; and detailed records must be kept for all applications.

Table 1. 1992 Atrazine rate restrictions (lbs/ac a.i.).

Soil texture	Statewide restriction		AMA
	Used last year	Not used	
Coarse	1.0	1.5	0.75
Medium/Fine	1.5	2.0	1.00

Evaluation Methods

Questions guiding this evaluation of theAtrazine Rule were two-fold; does the existing Atrazine Rule work, and if so, what are the impacts on Wisconsin corn farmers? The question of whether the Atrazine Rule works was analyzed by examining weed management strategies used by samples of Wisconsin corn growers. The research was not intended to empirically examine the transport or fate of atrazine relative to groundwater. Instead, the research is based on the assumption that changes in human behavior (i.e., farmers' use of atrazine) will result in changes in the type, amount and relative risk of contaminants reaching groundwater.

The question of impact determination relative to the Atrazine Rule is more complex than the assessment of the Rule's efficacy. Here one must determine the nature, strength and distribution of a wide array of potential impacts. While the cost of controlling weeds in corn is often cited as the principle impact of the Atrazine Rule, other potential impacts include changes in the relations between farmers and agrichemical dealers, shifts in enterprise mixes, alteration of future crop production plans, adoption of non-herbicide alternatives, and a precedent for increased public participation in decision-making on private land.

Table 2. Atrazine rates by corn rotation and restriction status.

Status	Atrazine rates (lbs/ac a.i.) by corn rotation				
	Continuous	1st year	Other	Last year	Total
AMA	0.7**	0.9	0.7*	0.6	0.7**
Non-AMA	1.1**	1.0	1.1*	0.5	1.0**

* significantly different at the 0.05 level
** significantly different at the 0.01 level

In order to measure how AMA designation altered behavior relative to atrazine, it was necessary to delineate a comparison or control area for each AMA. Each AMA was matched with a comparison area on the basis of 1) geographic proximity, 2) soil and hydro-geologic characteristics, and 3) farm sizes and types. After delineating the comparison areas, random sampling was employed to identify corn producers in AMAs and control areas.

A mail survey process was used to contact 1062 corn producers. A sampling error of 0.04 was used to calculate initial sample sizes. Those numbers were then inflated to account for expected non-response rate. Total final response rate was 52%.

In order to collect information of sufficient detail to compare weed management settings and strategies across cases and regions, we collected specific data on the weediest corn field in the 1992 production year. Additional information was collected on non-atrazine weed control practices, farm/firm characteristics, and knowledge of responsibilities under the Atrazine Rule.

Findings

The matched sampling proved highly effective with no significant variation between AMA and non-AMAareas. This supports the assumption that observed differences in weed control strategies are attributable to restrictions under the Atrazine Rule.

Relative to non-AMA areas, AMA farmers have decreased extent and intensity of atrazine use. This is an indication that the Atrazine Rule has accomplished its goal of reducing field applications of atrazine. In terms of extent, only 48.4 percent of AMA farmers were using atrazine on their weediest corn field as compared to 60.8 percent for non-AMA farmers. Relative to intensity, AMA farmers using atrazine are applying at significantly lower rates than their counterparts in control areas (See Table 2). The observed differences in rates across corn rotations represent persistent concerns regarding atrazine carryover despite the low rate of application. Violation of rate restrictions for the AMA and non-AMA control areas were 10.6 percent and 1.5 percent, respectively. In most cases these violations were due to the use of a pre-blend tank mix where

maximum allowable rates were exceeded by only a few tenths of a pound active ingredient per acre. We found no flagrant violations of rate restrictions. These results indicate that relatively low rate atrazine application remains a popular component of weed management strategies.

A significant number of respondents were confused regarding the restriction status of their weediest corn field. The mail survey instrument contained a map where respondents identified the approximate location (quarter section accuracy) of their weediest corn field. Over 14 percent of the AMA respondents failed to recognize that the sampled field was inside an AMA, and 48.3 percent of the non-AMA control farmers mistakenly reported that their sampled field was inside an AMA. Over-estimation of level of restriction may explain the relatively low application rates observed in the control sample. Additionally, fewer than 75 percent of respondents correctly identified atrazine as an ingredient in several popular pre-mixed herbicides. This indicates a critical information gap underlying implementation of the Rule.

Relative to their counterparts in non-AMA areas, farmers operating within an AMA are not facing an agronomic disadvantage as represented by comparisons of yield loss predictions and assessments of weed intensity. The overall mean reported increase in per acre weed management costs associated with a total ban on atrazine ban was $11.48. As measured during this first growing season, the 1992 Atrazine Rule appears to have triggered no changes in corn production plans or future farm planning.

Field size and farm size were found to have a significant positive correlation with use of atrazine (Chi-square=10.6, 4 df and 13.2, 3 df, respectively). That is, larger farms have larger fields and are more likely to be using atrazine on their weediest corn fields. However, the rates of atrazine application were not found to be correlated with either field size or farm size. Because field size is positively correlated with farm size ($p<.01$), larger farms as a group may face a more pronounced adjustment to atrazine restrictions.

Product substitution appears to be the near-term response to the Atrazine Rule as supported by two findings: 1) farmers who did not use atrazine on the weediest corn field were significantly more likely to use non-atrazine herbicides than were atrazine users, and 2) AMA farmers were significantly more likely to use non-atrazine products than were non-AMA farmers. More sophisticated transition strategies appear to be emerging. For a variety of non-atrazine alternatives (non-atrazine herbicides, reduced rate applications, banding, cultivation and rotary hoeing, and weed scouting), across a range of evaluation criteria (risk, profitability and labor requirements), farmers who did not use atrazine consistently reported more favorable assessments than did atrazine users. This result is consistent with research findings regarding the early stages of the adoption process (Rogers, 1983). It is likely that these more complex patterns will require several seasons to crystalize.

In general, a major conclusion of this study is that the Atrazine Rule has achieved its objective, i.e., the Atrazine Rule has reduced extent and intensity of use for this herbicide. The Rule has clearly accelerated existing trends in terms of decreases in rates and extent of use of atrazine in weed control. Wisconsin farmers have clearly demonstrated their willingness to meet restrictions even though they were able to identify significant additional costs to prevailing methods of corn production. Perhaps "surprising" and "gratifying" are the best terms to describe the high level of compliance achieved within so short of a time period. This is especially true when comparing this program against other large-scale, agricultural programs with environmental objectives, e.g., USDA's conservation compliance contained in the 1985 Farm Bill or the conservation provisions in Wisconsin's Farmland Preservation Program.

The 1993 amendments to the Atrazine Rule (legislative approval pending) require all atrazine users in the state to comply with restrictions similar to the 1992 AMA standards. The major exception is a limit of 1.5 lbs. ai per acre per year on medium and fine textured soil surfaces not receiving atrazine the previous year (1992 AMA = 1.0 lbs.). Areas designated as APAs have been expanded to cover over 400,000 ha. The decision to include atrazine metabolites in the calculation of a water sample's atrazine concentration has significantly contributed to the expanded prohibition area. Although this project represents an

assessment of the 1992 restrictions, these results can be used to estimate probable impacts from the 1993 amendments to the Atrazine Rule.

Future Research

These data indicate that the Atrazine Rule will reduce atrazine loading to groundwater to the extent that these water resources were contaminated by past field surface application of atrazine. Yet in order to capture the full range of impacts associated with atrazine restrictions (notably, the pending 1993 amendments), measurement will be necessary across a greater time span. It will be important to understand the farmers' perceptions of incentives and obstacles in moving from short-term product substitution to more comprehensive changes in weed management strategies. Gaining an understanding of these obstacles and incentives early in the transition process offers the opportunity to manage for desireable outcomes. This study should be considered a baseline against which later analysis can be compared.

At this time a study is underway to assess the impact of the Atrazine Rule on Wisconsin's agrichemical supply industry. Intuitively we know that the industry has been impacted by the Atrazine Rule and that agrichemical suppliers are major factors influencing the weed management strategies employed by farmers. However, facts and an objective assessment of these issues are not available. Additionally, research has been proposed to evaluate the potential relative contribution of farmstead design (i.e., point and quasi-point source potential) versus field application (nonpoint source potential) to the current groundwater problem.

PART I

I. Context of the Atrazine Rule

Several issues important to an evaluation of the Atrazine Rule are discussed below. First is a brief summary of the evolution of the Atrazine Rule. As will be seen, these regulations were a reasoned response mandated under law to a growing recognition of a problem. Yet there is more than a legal context to the Atrazine Rule. There is also an historic and agronomic context to the Atrazine Rule. Two trends warrant attention to establish the context of this report. The first is atrazine's declining popularity with farmers, and the second is the status of alternative means of weed management.

EVOLUTION OF THE ATRAZINE RULES

The rules that currently govern the use of atrazine in Wisconsin have seen many changes in the past few years. An abbreviated account of the evolution in the rules is provided here. For a more complete account of the rule-making process, consult the 1993 Environmental Impact Statement prepared by DATCP. Although the study discussed in this report is based on the 1992 growing season, the rules governing the 1993 growing season will be described as well.

Chapter 160 (Wisc. Stats.), the Groundwater Law, created specific responsibilities on the part of state agencies in situations where groundwater pollution problems have been identified. As required by the Groundwater Law, the Wisconsin Department of Natural Resources (DNR) proposed pollutant concentration "triggers" at which remedial and preventive activities are required. The DNR in creating groundwater standards based their decision on the recommendations of the Wisconsin Department of Health and Social Services (DHSS) who in turn relied on toxicological research findings. These contaminant standards were subsequently adopted by the legislature (NR 140). Specifically, this law defines the *preventive action limit (PAL)* for atrazine to be 0.35 ppb. Above the PAL threshold, DATCP is responsible to take action to prevent further degradation of groundwater. Under conditions where the PAL has been exceeded, Wisconsin law supports the designation of priority management areas and the creation of supplementary rules.

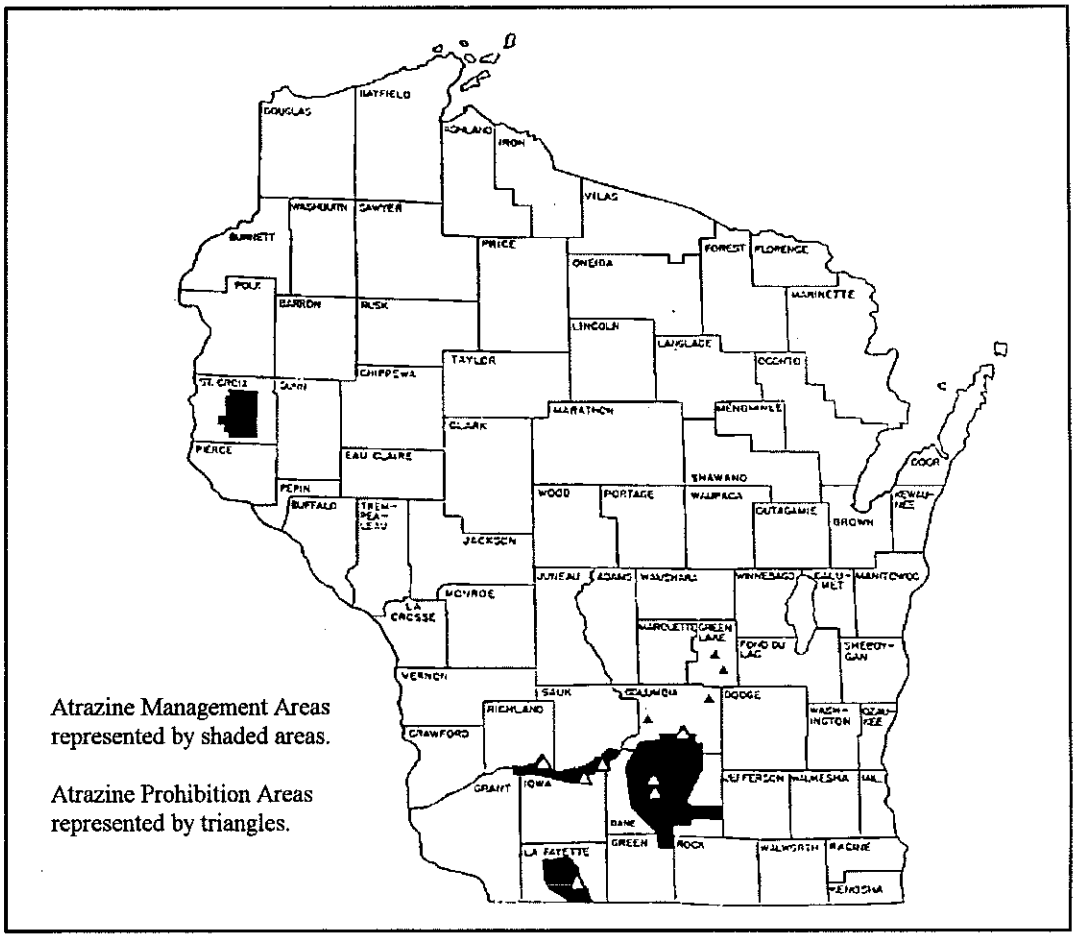
NR 140 also specified the *enforcement standard (ES)* to be 3.5 ppb. In 1991, the DNR lowered the Wisconsin ES to 3.0 ppb to match the U.S. Environmental Protection Agency (EPA) standard for atrazine. At this level of contamination DATCP is responsible for designating an APA and prohibiting use of atrazine in the immediate area. DATCP must exercise judgement in the application of these rules in cases where circumstances indicate an alternative approach would be desirable. Another area in which DATCP has been left to make difficult choices is the determination of AMA and APA boundaries. Due to the nature of groundwater (U.S. General Accounting Office, 1991, Oct.), and the complexity and cost of groundwater monitoring (U.S. General Accounting Office, 1991, April; Lee, 1987), much of this process is necessarily subjective (Ehrman, 1990).

DATCP began a series of well-water testing studies in August of 1988 that provided the atrazine contamination data leading to the first round of restrictions (Grade A Dairy Farm Well Water Quality Survey, DATCP, 1989). In 1990, 1800 acres of the Lower Wisconsin River Valley became the first area to carry an atrazine prohibition through a program of voluntary consent.

In March 1991 the Atrazine Rule (Ag 30, Wisc. Adm. Code) became law. The Atrazine Rule established maximum atrazine application rates and conditional use restrictions for the state. It also established a series of overlay zones, areas in which additional restrictions are imposed on top of the statewide rules. The statewide restrictions and the overlay zones represent a hierarchical, three-tiered management structure. In ascending order of limitations on atrazine, the levels of restriction are referred to as statewide restrictions, Atrazine Management Areas (AMAs) and Atrazine Prohibition Areas (APAs).

Maximum atrazine application rates to a given field are determined by three criteria: atrazine usage the previous year, field surface soil texture, and position relative to overlay zones.

Figure 1. 1992 Atrazine overlay zones (DATCP).



The statewide rates allowed under Ag 30 varied from a maximum allowable rate of 2.0 lb. ai/acre per year on medium and fine textured soils on which atrazine was not used the previous year to a maximum of 1.0 lbs. ai/acre per year in situations where the soil was coarse and atrazine had been used the previous year.

The 1991 Atrazine Rule contained additional restrictions on the use of atrazine:

1) Atrazine can only be applied between April 15 and July 31 in any calendar year.

2) Non-row crop applications are prohibited. Most notably railroad rights-of-way may no longer be treated with atrazine. Forestry applications are allowed under the law.

3) Atrazine cannot be applied through an irrigation system.

4) Irrigation on a field treated with atrazine must have an irrigation scheduling program in place to prevent field moisture capacity in the root zone from being exceeded.

5) Certification became a requirement for people who mix, load or apply atrazine.

6) Detailed records of atrazine application must be kept for three years following use.

7) The first Atrazine Management Area (AMA) was established along the Wisconsin River between Sauk City and Boscobel. In this area, the maximum atrazine application rate on sandy soils was set at .75 lb. ai/year.

8) Six Atrazine Prohibition Areas (APAs) were established.

In March of 1992 five additional AMAs and eight additional APAs were created (see Figure 1). All previous restrictions continued to apply. The rate restrictions were the same as those of the 1991 Rule (see Table 3). An additional requirement was placed on the Lower Wisconsin River Valley AMA in that irrigation was not allowed under any circumstances for two years following application of atrazine. Furthermore, a rescue treatment provision for seed and sweet corn was added. Under this rescue provision, growers may apply additional atrazine though overall use may not exceed the statewide restriction levels. These rules governed the 1992 growing season.

Table 3. 1992 atrazine rate restrictions (lbs ai/acre/year).

Soil Texture	Statewide Restriction		AMA
	Used last year	Not used	
Coarse	1.0	1.5	0.75
Medium/Fine	1.5	2.0	1.00

In 1992, largely due to an improved ability to detect atrazine metabolites, the standard by which atrazine concentrations were determined was changed. DATCP with the assistance of Ciba-Geigy, the original U.S. manufacturer of atrazine, upgraded the laboratory procedures used to analyze groundwater quality. Through these more sophisticated and expensive laboratory tests it became possible to identify increasingly small quantities of not only atrazine but also the breakdown products of atrazine. A decision was made to include these breakdown products of atrazine, referred to as atrazine metabolites, in addition to the parent atrazine detections. Parent atrazine refers to atrazine in its original molecular configuration prior to disaggregation into its metabolites. The determination of the concentration of atrazine in a water sample would now be made through an analysis of the summed total of the parent atrazine and three metabolites:

Total atrazine = (atrazine + deethyl atrazine + deisopropyl atrazine + diamino atrazine)

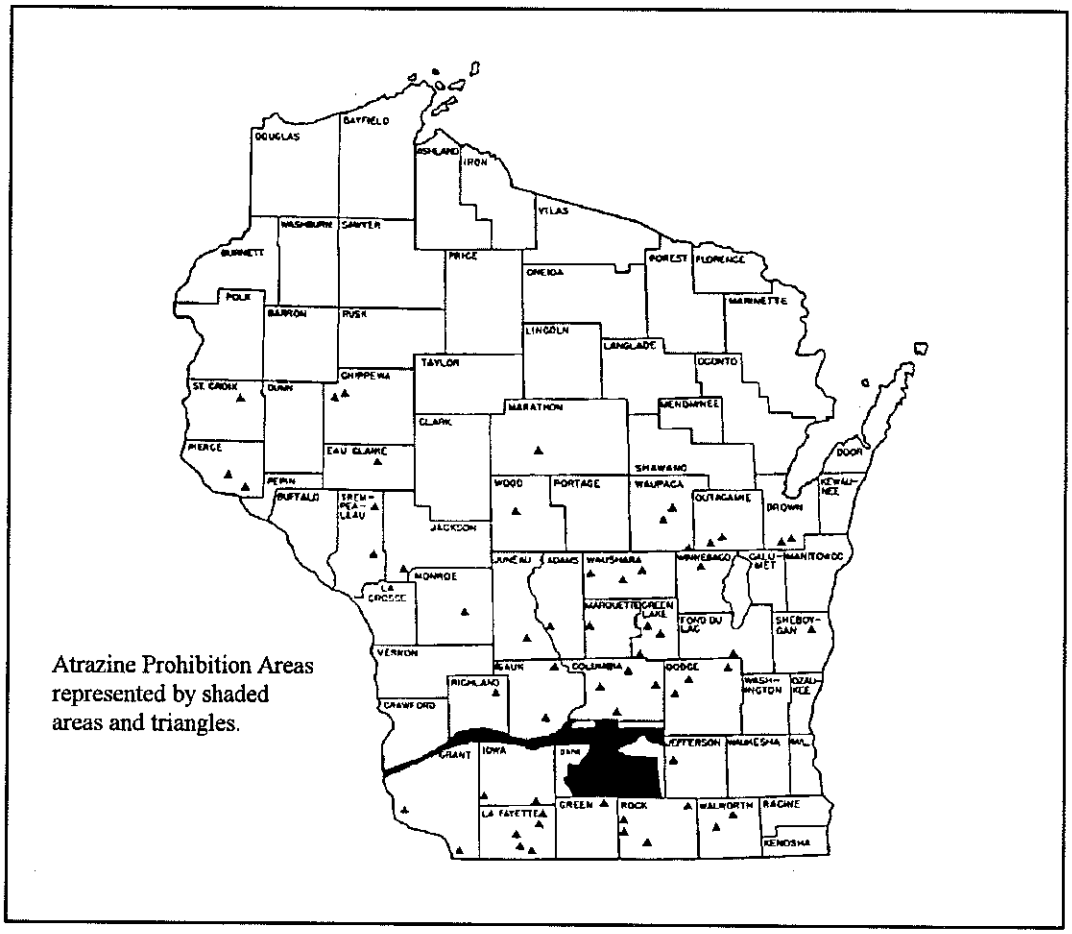
The only known source of the metabolites is parent atrazine. If a sample found to contain metabolites had been analyzed at an earlier time, it can be assumed the metabolites would be present as parent atrazine (Ragone, 1988). In this sense, the additive principle of parent atrazine plus metabolites is simply an extension of the ability to measure the extent of atrazine contamination. The immediate effect of this change was the increased likelihood that a well water sample would exhibit an atrazine concentration over the limit demanding a response from DATCP.

Additionally, the time that had elapsed since the introduction of Ag 30 had allowed for a considerable number of wells to be tested. This sampling continued to provide information regarding the geographic extent of contamination (Mechenich, 1990). Samples taken from corn production areas around the state in 1992 indicated that 42 percent of wells contained triazine (DATCP, 1992). Triazine is used as a surrogate measure for atrazine because the laboratory procedure considered most cost-effective with a strong correlation between the concentration of triazine and parent atrazine. In these same wells, 13 percent exhibited detections over the PAL and 1.5 percent exhibited detections over the enforcement standard. This procedural change regarding the manner in which the pollutant concentration is calculated is important in that the water quality did not change, but what did change is the way quality is defined. The effect of this change is that the level of restriction (i.e., AMA or APA designation) applied to an area under the original procedure could be different from what it would be if the same water samples were analyzed under the new standards.

The 1993 Atrazine Rule contains significant changes due to the newly recognized geographic scope of the contamination and the inclusion of metabolites in the pollution concentrations (Hill, 1992). The statewide maximum application rates resemble those of the 1992 AMAs. The maximum application rate is 1.0 lb. ai/year for use on fine or medium texture soils. On those fields with fine or medium textured soil, if atrazine was not used the previous year, up to 1.5 lbs. ai/acre can be applied. On coarse textured soils the maximum application rate is 0.75 lb. ai/acre per year. A rescue treatment provision for sweet and seed corn growers still holds. Under this rescue provision, on coarse textured soils, growers may apply additional atrazine though overall use may not exceed a total of 1.5 lbs. ai/acre per year. On fine and medium soils, additional atrazine may be applied though overall applications may not exceed 2.0 lbs. ai/acre per year.

While the 1993 rules are more restrictive than the 1992 rules, some producers operating in areas with documented atrazine contamination of groundwater have become less restricted relative to use of atrazine. Producers who farm on medium or fine textured soils inside a 1992 AMA

Figure 2.
1993 Atrazine overlay zones (DATCP).



and did not apply atrazine during 1992, are eligible to apply up to 1.5 lb. ai/acre in 1993. Under the 1992 rules, these producers would be limited to 1.0 lbs. ai/acre.

Because the new 1993 statewide limit is almost identical to the 1992 AMA limits, AMA designations have been eliminated. The largest 1992 AMA, greater Dane County, has been designated an APA for 1993. The boundaries of the 1992 Dane County AMA and the 1993 Dane County APA are not identical. An additional 54 prohibition areas have been proposed (Figure 2). These amendments to Ag. 30, if approved by the legislature, will increase the atrazine prohibition area to over 400,000 ha (one million acres).

HISTORY OF ATRAZINE USE

Atrazine is the name recognized by the American National Standards Institute for the compound 2- chloro - 4 - ethylamino - 6 - isopropylamino-s-triazine. Atrazine was first licensed in 1959 as a pre-emergent herbicide used in corn production. Since that time, as the leaching potential and reduced rate efficacy became better recognized, the recommendations for rates of application have declined.

Up until Wisconsin adopted the Atrazine Rule in 1991, the federally licensed label dictated the maximum rates of application allowable under law. Now that Wisconsin has adopted stricter guidelines, the state standards take precedence. From 1959 until 1991, the maximum application rate allowable on cropland was 4 pounds[1] (Bondarenko, 1960; Ciba-Geigy, 1990). Following a voluntary label amendment offered in 1991 by the manufacturers of atrazine, the maximum rate for cropland application decreased from four to three pounds (Ciba-Geigy, 1991). The 1991 label amendment also included a warning statement which declared atrazine to be a *restricted use pesticide* due to groundwater concern. The label now carries the following statement:

[1] All application rates will refer to pounds active ingredient per acre per year.

"I know . . . five to seven pounds of atrazine were used by some [farmers]. I [have] seen fields that were literally colored white with atrazine."

-- Survey respondent comment

RESTRICTED USE PESTICIDE
GROUNDWATER CONCERN

For retail sale and use only by certified applicators or persons under their direct supervision and only for those uses covered by the applicator's certification.

This product is a restricted-use herbicide due to groundwater concerns. Users must read and follow all precautionary statements and instructions for use in order to minimize potential for atrazine to reach groundwater.

The maximum application rates described above were not the rates recommended for average field conditions. Under "normal" conditions, the label called for application of 2.0 pounds. The 2.0 pound recommendation has remained consistent over time (Doersch, 1974; Doersch, 1981; Ciba-Geigy, 1991). Since the mid- 1970's it has been recognized that lower rates were capable of providing adequate weed control under favorable soil conditions and/or under conditions of low intensity weed competition (Doersch, 1972). Exceptions to this recommendation were offered for conditions of 1) heavy soils[2] and 2) problem weed outbreaks.

Because of the need to increase rates of atrazine under heavy soil conditions in order to maintain control over weeds, it is possible that the 1992 atrazine restrictions have created significantly different impacts in those areas of the state featuring these soils. It is possible that restricting rates of application to 2.0 pounds in areas of heavy soils represents a more significant constraint on atrazine use than similar restrictions in areas without heavy soils.

The label called for higher rates to control problem weeds such as Giant Foxtail and Quackgrass. Grass problems such as those associated with Quackgrass were widespread in Wisconsin when rotating out of several years of alfalfa into corn. The recommendations offered to manage outbreaks of these weeds remained consistent from atrazine's introduction up until 1991. The recommendation was for a split application of 4 pounds of atrazine. Half was to be applied several weeks before planting with the remainder applied at planting or shortly thereafter. Alternatively, a single application of 4 pounds could be applied 2-4 weeks before planting. When rates such as these were required, the label suggested that a second year of corn or sorghum follow the initial year in order to avoid damage from herbicide carry-over (Doersch, 1974; Ciba-Geigy, 1990).

Atrazine carry-over results from a percentage of the herbicide remaining active in the soil during the following growing season. Crops commonly grown in rotation with corn, such as soybeans and alfalfa, are susceptible to damage from atrazine (*Wisconsin Agriculturalist*, 1959). If atrazine is active in the soil when a susceptible crop is planted, crop damage may occur. The lack of flexibility in crop selection associated with an atrazine-based weed control strategy is thought to be partly responsible for the declining popularity of atrazine. Dynamic markets, narrow profit margins, uncertainties associated with federal commodities programs, and more recently environmental concerns demand flexibility in crop selection. Because of restrictions in flexibility due to potential carry-over, farmers are exploring other options.

Non-crop use of atrazine has been the area which has seen the most significant reductions in allowable rates. The original label recommendations for non-crop uses such as transportation rights-of-way and building foundation maintenance called for 40 pound rates (Ciba-Geigy, 1990). Following the amendments to the product label in 1991, this recommendation was changed to 10 pounds. The Atrazine Rule prohibited non-crop use of atrazine in Wisconsin. Very little is known about the extent of non-crop uses of atrazine and their contribution to the current groundwater contamination.

This brief summary of label recommendations indicates that there has been little change since the introduction of atrazine in 1959 up until

[2] Heavy soils refer to those soils with either a high clay content or a high percentage of organic matter (>4%). Due to increased surface area per unit volume ratios associated with these soils, the herbicide is adsorbed more readily and held more tightly by the fine particles present under these conditions. Under these field conditions, the recommended application rates were increased to 4.0 lbs. on the 1960 label (Bondarenko, 1960). The 1964 label called for 3.75 lbs. for use in heavy soils (*Wisconsin Agriculturalist*, 1964).

"Chemical dealers have been very anxious to sell chemicals in the last ten years. Too many farmers have been over-run with people telling us what to do and how to do it."

-- Survey respondent comment

1991. Recommended rates under "average" field conditions have consistently been set at 2.0 pounds. Rates have been set at 4.0 pounds only under conditions of heavy weed pressure or heavy soils. This illustrates that Wisconsin farmers have had long experience with moderate use of atrazine. Abuse of atrazine in the past (i.e., field applications significantly higher than those recommended on the label) has been reported. The contributions of historic over-application and non-crop applications of 40 pounds/acre to the current groundwater problem are unknown.

WEED MANAGEMENT IN CORN PRODUCTION

Weed control has long been a critical element in corn production. Herbicides, particularly atrazine-based products, have been a major part of these control programs in recent decades. Despite the downward trend in reliance on atrazine, this herbicide remains in wide use in Wisconsin (DATCP, 1991; WASS, 1991) and around the nation. In 1986, 55 percent of all herbicides used on U.S. field crops were applied to corn; atrazine was reported to be the second most widely used herbicide in the United States; and herbicide purchases account for about 62 percent or $2.5 billion of the $4 billion spent on agrichemicals in the U.S. (NRC, 1989). In 1990, 56 percent of the Wisconsin corn crop was treated with atrazine at an average application rate of 1.43 pounds (DATCP, 1992).

Like many components of agriculture, environmental considerations have created a situation where many traditional recommendations for weed management are being critically reexamined. The Atrazine Rule comes at a time when other agrichemical regulations are being considered (Neher, 1993), the public's perception of costs and benefits associated with agrichemicals is changing, the impact of agrichemicals on the environment is becoming better understood, and agrichemical technologies themselves are changing.

The Atrazine Rule is predicated on the belief that alternatives to atrazine exist. In a sense the atrazine regulations are technology forcing (Baker, 1990) -- forcing in the sense that the rules themselves do not address replacement technologies. Rather, the restrictions generate a need, and necessity is thought to induce invention. There is a long line of agronomic and horticultural research that demonstrates non-atrazine weed control strategies can be effective under certain conditions. An unanswered question remains as to how robust these technologies are when put to the test of widespread, consistent application.

It is not clear whether these alternatives can function as the mainstay of a weed control program. What will be the cost to the farmer? Will reliance on alternative non-atrazine chemicals result in a repetition of the current regulatory process directed toward another agrichemical? Can the alternative technologies carry the agronomic burden without the safety net an atrazine rescue treatment has offered in the past? Will reducing the variety of herbicides applied to weeds result in herbicide resistant weed populations? To what extent will these non-atrazine alternatives be appropriate on farms with labor or managerial limitations? These questions will play a role in determining the success of Wisconsin's Atrazine Rule.

Two technical issues are important to determining the answers to certain of the questions posed above. The first is the ability of Integrated Pest Management (IPM), or more accurately, Integrated Weed Management (IWM) to meet the potential as a technique capable of economically managing weeds while reducing the pollution potential of weed control operations. The second issue concerns replacement herbicides. It is highly likely that one of the initial impacts of the Atrazine Rule will be an increase in alternative herbicides (i.e., product substitution).

Integrated Weed Management (IWM)

Integrated Weed Management is a generic heading applied to weed control strategies that analyze the impact of weed competition on a crop in combination with other considerations. Most often the other consideration is an economic one. There is increasing interest in integrating environmental considerations associated with weed management into the process of strategy selection. Generally, IWM is defined as a process of applying a test of economic rationality prior to making a decision to carry out a control treatment. If the economic injury of non-treatment exceeds the cost of a control option, then the control operation should be executed. The test of economic rationality can be applied against a

"I believe atrazine is safe when used properly."

– Survey respondent comment

wide number of control options to determine what actions or inactions optimize net financial returns.

Including the external costs of environmental damage is more problematic in this model of economic rationality. The external costs are those not directly borne by the producer, but are passed on to the larger society in the form of environmental degradation. The difficulty involved in establishing monetary values and factoring external costs into an economic assessment make it unlikely that environmental considerations will weigh heavily in an IWM analysis as described above. Environmental benefits of IWM are derived by reducing the amount and rate of herbicide applications, and through promoting more environmentally benign control strategies. Source reduction is the single best way to manage environmental risks (Haimes, 1991).

Of course, to make a decision to spend a dollar to save two dollars does not require an acronym. IWM is, in a general sense, a contextual approach to weed management that recognizes weeds as part of a larger system. Today's knowledge of weed science is substantially more detailed than it was only a short time ago. This increased depth of understanding has led to contemporary weed management recommendations becoming increasingly site and/or problem specific. The complexity of state-of-the-art weed control has also been accompanied by a host of complicating factors such as regulation, liability, environmental concerns, and health and safety concerns (Centner, 1990; Fleming, 1988).

An important implication of the increasing complexity in current agricultural technology is that management, the skill of the producer in fitting the pieces together, is becoming more important. Herbicides can no longer be viewed as a simple, labor-saving technical fix as in the past. IWM was founded in response to complexity. Decisions must be made in recognition of impacts at several levels - economic, agronomic and ecological (Lowrance, 1987). The current trend is away from quick technical fixes that fulfill their function regardless of the managerial sophistication of the applicator. Instead, the trend is toward management intensive practices which may require farmers to seek educational opportunties or professional support services (i.e., crop consulting, custom application of pesticides). It is in this sense that human capital, enriched through education and experience, is an important asset in agriculture's attempt to protect or enhance the environment.

The demand for increased expertise in application of technology is evident in the non-atrazine weed control alternatives selected for study in this research. These weed control options, for the most part, demand higher levels of time, training, and analytic skill from the applicator. There are a variety of non-atrazine based weed control techniques such as:

1) ***Non-atrazine herbicides:*** any chemical control that does not include atrazine as an ingredient.

2) ***Herbicide banding :*** application of herbicides on planted rows only thereby decreasing volume applied per acre.

3) ***Below label rate applications:*** use of an herbicide at rates below the manufacturer's recommendation (Doersch, 1992; Doll, 1992).

4) ***Mechanical control of weeds:*** physical disruption of weed growth through use of cultivation equipment (Land Stewardship Project).

5) ***Weed scouting:*** analysis of type and severity of weed outbreak prior to making treatment decisions (Harvey, 1992).

6) ***Crop rotation:*** planting a revolving cycle of crops on a single field to maintain favorable growing conditions.

Each of these techniques could be interpreted as a component of IWM, and in general, each requires increased levels of sophistication on the part of the producer. At issue is both the extent this sophistication is present in Wisconsin agriculture, and the extent it is being promoted and supported though the private and public sectors.

Non-Atrazine Herbicides

Non-atrazine herbicides require study to insure they are capable of controlling weeds across a range of growing conditions and that they do not pose a greater environmental risk than does atrazine. If one or both of these suppositions are incorrect, the water quality benefits associated with the Atrazine Rule may come at a high cost to Wisconsin's farmers or the environment.

The decision to restrict atrazine applications in the absence of catalysts to promote non-chemi-

cal means of weed control implicitly invites increased use of non-atrazine herbicides. This trade-off is regarded as favorable in the DATCP 1991 environmental impact statement:

> Alternative herbicides, because of differences in mobility and persistence, do not generally have as great a potential to contaminate groundwater as atrazine. Certain other corn herbicides, such as alachlor, metalachlor and cyanizine, have been found in groundwater, but not nearly as frequently as atrazine. Increased use of alternative herbicides is not expected to have a significant adverse impact on the environment.

There is an additional concern that reliance on a narrowed spectrum of herbicides will lead to weed cultivars that quickly develop resistance to herbicides (*Farm Industry News*, October 1992). The majority of herbicides likely to be used in place of atrazine function through an enzyme inhibitor, aceto-lactose- synthase (ALS). This inhibitor controls weeds by blocking the weed's ability to carry on metabolic function. This reliance on a single lethal mechanism, or mode of action, creates an opportunity for weed cultivars impervious to this particular control vector to quickly become major problems (Proust, 1993; Doersch, 1992). It is unknown at this time whether this scenario will come to pass.

"By using atrazine in moderate amounts and having atrazine premixes, it is much easier to control weeds. A ban on atrazine would really hurt farmers."

-- Survey respondent comment

Another issue that has been raised informally is that some non-atrazine herbicides are so highly concentrated that attempting to monitor for pollution will be technically infeasible. The application rates for some of these compounds is in the range of ounces per acre. Conceivably, highly concentrated herbicides are capable of causing environmental damage and/or human health impacts in minuscule amounts. These minuscule concentrations may be beyond the range of detection.

A major concern regarding farm level impacts of the Atrazine Rule is the price differential between atrazine and non-atrazine alternatives. It has been hypothesized that the low price of atrazine relative to other herbicides is partially responsible for it being detected in groundwater. Atrazine has been applied in amounts disproportionate to other agrichemicals. Further, it was so cost-effective that "insurance" applications (i.e., applications above and beyond recommended rates) have been reported in numerous anecdotal accounts. Overall, it would appear that farmers confronted with the prospect of switching from atrazine to a non-atrazine alternative will incur some level of cost.

In the Environmental Impact Statement produced by DATCP for Ag. 30 (January 1991), a farm enterprise budget model was used to analyze per acre costs of non-atrazine and low-atrazine alternatives under a variety of physical, agronomic and atrazine restriction scenarios. Estimated cost increases ranged from $0.42 to $20.59 per acre. These data are supported by a recently published estimate of $11 additional cost per acre associated with a switch to a non-atrazine herbicide in Jefferson County, Wisconsin (*Dealer Progress*, 1993).

Even in cases where net chemical costs are reduced, mechanical weed control and/or other alternative measures involve increased costs. Weed scouting, for example, involves out-of-pocket expense if the producer hires out the job, or does the scouting personally. There are also expenses associated with the adoption of these alternative techniques including learning and transition costs. Moreover, labor shortages during critical periods during the production cycle may preclude certain operations from adopting these alternatives. Other instances would be where dairy operations are forced to decide where limited human capital (i.e., managerial expertise) will be allocated: on herd production which generates the farm's income through milk checks, or on crop production activities that only generate a feed input to the dairy herd?

The availability of effective, reasonably priced herbicides (Hollingworth, 1991) along with the ability to manage increasingly complex technologies will determine final adjustments to the Atrazine Rule. The number of variables involved insures that a single account of the transition costs and process will be an inadequate description. On different farms the length of the period of adjustment will vary, the cost of the transition will vary, and the secondary impacts or ripple effects associated with the introduction of atrazine alternatives will also vary. This study does not claim to fully represent the range of physical settings or farming systems in the state. Additionally, measurements made across time are required to fully understand all the impacts of the Atrazine Rule.

II. Objectives of the Study

This project was supported by the Wisconsin Department of Agriculture Trade and Consumer Protection (DATCP) with additional funding from Ciba-Geigy. Questions guiding this research were two-fold: does the existing Atrazine Rule work, and if so, what are the impacts on Wisconsin corn farmers? The question of whether the Atrazine Rule works will be analyzed by examining weed management strategies used by Wisconsin corn growers. The research is not intended to empirically examine the transport or fate of atrazine relative to ground water. Instead, it is based on the assumption that changes in human behavior (i.e., farmers' use of atrazine) will result in changes in the type and amount of contaminants reaching groundwater.

The question of impact determination relative to the Atrazine Rule is more complex. Here one must determine the nature, strength and distribution of a wide array of potential impacts. While the cost of controlling weeds in corn is often cited as the impact of the Atrazine Rule, other potential impacts include changes in the relations between farmers and agrichemical dealers, shifts in enterprise mixes, alteration of future plans, and adoption of non-herbicide alternatives. Further, this study does not propose to examine any of the inter-state or international competitiveness issues. Instead it will focus on the above impacts and how they may be distributed among farm types, scale and location in Wisconsin.

One final assumption guiding this research was that measuring changes in behavior and impacts of those changes would require measurements at several points in time. Consequently, this report only presents the baseline data set as part of a larger research design. As a result, analysis of baseline data alone cannot meet all stated objectives at this time. In cases where measurement is required over several growing seasons no attempt is made to predict the future. In cases where informed speculation is possible the authors have applied the data as appropriate.

In summary, the primary objective of the research was to determine the nature, extent and distribution of impacts that an Atrazine Management Area (AMA) designation has on weed management strategies in corn production when compared to non-AMA regions of Wisconsin. This research was also designed to provide data relevant to a periodic review of the provisions of the Atrazine Rule as specified under Ag. 30.

STATEMENT OF PURPOSE

The impact of the Atrazine Rule on weed control in corn production was hypothesized to be reflected in the knowledge and behavior of corn producers. It was argued this knowledge and behavior would be translated into agronomic decisions with economic and environmental implications. It was further hypothesized that the nature and extent of these impacts will vary between the AMA's and the non-AMA corn production areas of the state.

To test the above hypothesis it was necessary to measure knowledge and behavior among a representative group of corn producers both within and outside of an AMA. Control for variables other than AMA designation had to be established.

In order to accurately document changes in active ingredient atrazine applications and other variables, it was desirable to collect data at the field level rather than the farm level. This procedure generates agronomic data for a smaller land area, but the level of detail required to assess agronomic transitions requires such a compromise. The data collection protocol applied to this research, in relative terms, would be accurately described as intensive rather than extensive.

RESEARCH OBJECTIVES

Data was collected relative to the following objectives:

Objective 1: To measure knowledge of the Atrazine Rule including factors determining amount of product allowed, record keeping requirements, and implications of operating inside an AMA.

Objective 2: To measure changes in corn production techniques resulting from passage of the Atrazine Rule. This will include crop rotations, IPM techniques, and adoption of non-atrazine alternatives.

Objective 3: To measure the soil texture class on corn fields, and relate this to the factors measured under objective two.

Objective 4: To measure herbicide use (type and rate) with an emphasis on atrazine products, certified pesticide applicator status, and use of custom application services on the corn fields measured under objective three.

Objective 5: To measure the nature and extent of influence agri-chemical dealers have relative to the knowledge and decisions specified under objectives one through four.

To meet the stated objectives and make the data accessible to readers with different interests, the research will be reported in two complementary sections. The first section, **Research Results,** will report data through descriptive statistics. Limited amounts of interpretation and analysis is provided where appropriate. The second section, **Focus Reports**, analyzes the data in an issues-oriented framework. Critical questions relating to the Atrazine Rule and the research objectives are explored through narrative reporting of the research results. These discussion papers allow the data to be focused on questions likely to be of interest to readers of this report.

The agronomic impacts of the Atrazine Rule are analyzed in the first report to determine how weed management strategies and cropping systems in general have changed in response to the new regulatory constraints. An argument for pursuing a gradual phase-out of atrazine as opposed to a sudden ban was that atrazine represented an important tool in a farmer's agronomic tool box. This position will be examined through application of the data.

The second report analyzes alternative (i.e., non-atrazine) weed management techniques that are likely to increase in popularity as atrazine use diminishes. As mentioned repeatedly in this report, analysis of a single growing season cannot stand alone as an indicator of change. To determine what farmers who had previously relied on atrazine will do in a situation where access to atrazine is restricted will require measurement across time and across a range of farming conditions. The current research design cannot address this issue. Instead, the available data set does provide an early indication of what is in use presently and what changes are likely to occur in the short term. The perceived viability of alternatives to atrazine as well as the impacts of an atrazine ban are discussed.

A critical issue in enforcing and evaluating rules is whether the target audience understands their responsibilities under the rules. In order to document the achievements of the Atrazine Rule, the extent of knowledge possessed by potential atrazine users must be determined. The third report discusses the research findings relative to the state of knowledge and identifies those elements of the policy most often misunderstood by farmers. These findings have important implications for future non-point source pollution management policy.

The diffuse pattern of potential pollution sources in a non-point situation makes control and enforcement a difficult task. For this reason education is regarded as an essential element in an overall non-point source pollution control strategy. In these situations, those people who potentially contribute to the pollution problem are the same ones in the best position to practice stewardship and take steps to avert the problem. The transition from potential polluter to steward requires that individuals are sensitized to the environmental risks associated with their actions. Because perception of risk is considered to be a critical element in the modification of behavior, the fourth report is devoted to farmers' perception of the quality and vulnerability of their groundwater.

STUDY FRAMEWORK

This research is an attempt to measure change and determine causality. The process presumes that the difference between two measurements, controlling for other variables, represents the impact caused by the action under study. The relationship between the system's elements determines the type and extent of the change. In this case, a regulatory requirement is thought to cause a change in producers' behavior.

Others have characterized the research protocol used here as quasi-experimental. A quasi-experimental research design acknowledges that "control" over potentially important variables is difficult to achieve for legal, political and ethical reasons. The problems of experimentation under such conditions have been discussed (Cochran, 1983; Lipsey, 1990). Rigorous application of data collection and analysis techniques has made it possible to overcome many of the problems associated with research of this kind (Isaac and Michael, 1981; Cook and Campbell, 1979).

III. Experimental Design and Methods

MATCHING AMA AND CONTROL (NON-AMA) AREAS

Data collection involved six counties -- Columbia, Dane, Green, Lafayette, Rock, and St. Croix. A research design was planned that would allow a comparison of the weed management practices and various other characteristics of farmers who farm within an Atrazine Management Area (AMA) with those who farm outside an AMA. To test for effects of the Atrazine Rule on farmers operating land within the AMA, comparisons were made to non-AMA areas where variables other than location within an AMA were held constant or "controlled." To accomplish this, each AMA was assigned a non-AMA control area of similar size at close proximity to the AMA boundaries. This was done to enhance the probability that characteristics such as farm size, enterprise mix, climate, soils/surficial geology, and agribusiness infrastructure would have a distribution similar to adjacent AMA features. Consequently, it can be argued that differences between weed management in the AMA and its control could not be attributed to differences in these matched variables. A design which investigates treatment effects using control areas is consistent with the recommendations of Cook and Campbell (1979), Cochran (1983), and Lipsey (1990).

Control areas were delineated using the following physical and agricultural criteria as guides:

1) Within the AMAs in each county (Columbia, Dane, Green, Lafayette, and St. Croix) square mile areas of each soil association were estimated through a process of overlaying outlines of each AMA on the soil association map for each county. The soil association maps are contained in the USDA Soil Conservation Service soil survey for each county. As closely as possible (soil association map scale was generally > 1:100,000), the number of square miles of each soil association within an AMA was matched with the same square mile area of the same or similar soil association within the control area. For example,

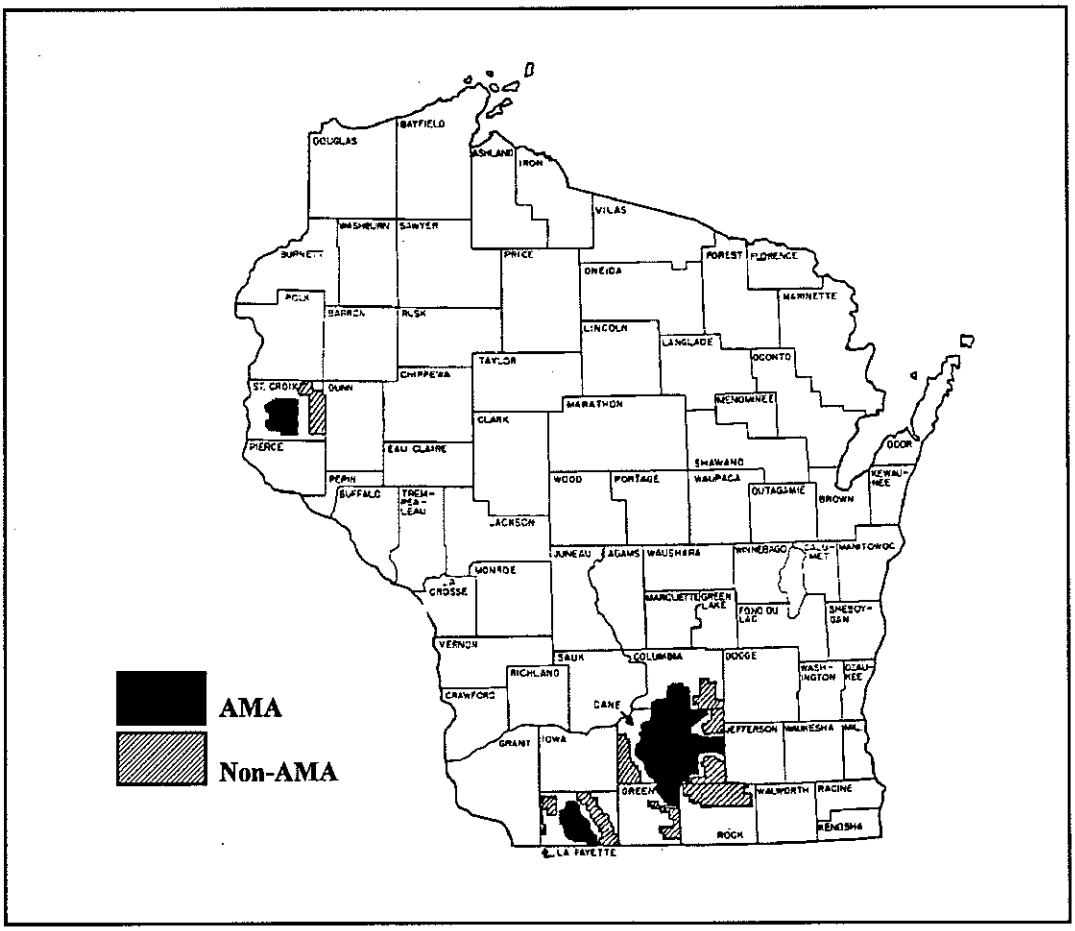


Figure 3.
Sampled areas.

Dane County non-glaciated soil associations were matched with non-glaciated soil associations in the control. Glaciated soil associations in Dane County were separately matched to glaciated soil associations in a second control.

2) Square miles of farmland in each control area was matched to the farmland area in the associated AMA. Non-agricultural areas were eliminated from the sample by excluding subdivided land, parks, and urban areas as determined by the most current *Land Atlas and Plat Book* (Rockford Map Publishers) for each county.

3) Control areas generally had proximal borders within one to five miles of the AMA match. This was done to control contagion effects of the Atrazine Rule caused by immediate contact while keeping the non-AMA match within the same general setting.

Table 4. Comparison of AMA and non-AMA on key variables.*

Variables	AMA	Non-AMA
Average income ($)	146,900	138,500
Acreage:		
Total tillable acres	395.0	383.2
Size of weediest field	33.1	30.4
Total corn acres	234.6	219.1
Years managed farm	21.7	21.9
Enterprise mix:		
% Dairy	39.0	38.9
% Livestock	19.3	18.3
% Cash crops	28.0	30.0
% Government programs	7.7	8.1
% Other	6.0	5.3
Dominant soil type:		
% reporting:		
Loamy	47.9	47.5
Clayey	39.9	41.4
Most problematic weeds:		
% reporting:		
Foxtail	36.1	37.7
Velvetleaf	21.7	18.7
Lambsquarters	8.9	9.3
Quackgrass	7.9	10.5

*No statistically significant differences observed.

The AMA areas in each county, except for Dane, were matched with non-AMA areas within the same county. Rock County was included as a non-AMA as part of the control for Dane County. This was partially due to the large portions of Dane County being included in an AMA (Figure 3).

It was also decided to distinguish the northern AMA and non-AMA (St. Croix county) from the southern AMA's and non-AMA's. Southern Wisconsin counties such as Columbia, Dane, Green, and LaFayette have distinctly warmer climates and more intense crop production than northern counties such as St. Croix. Weed regimes may also differ between these two climatic areas. Because St. Croix County was included in this research, these differences needed to be accounted for in the research design. To separate north from south and AMA from control, the sites were aggregated into four study populations: 1) Southern AMA's, 2) Southern Controls, 3) Northern AMA, and 4) Northern Control.

As shown in Table 4, our results indicate considerable success in matching AMA and control areas, in aggregate, on the key variables of farm size, enterprise mix, infrastructure, and soil types.

POPULATION AND SAMPLE SIZES

The number of farmers (population) and spatial area within each of the four population areas was calculated. These figures are contained in Table 5. Area measures were estimated through measurement of land area included in the study sites. Soil association maps and county plat books were used for this purpose. The number of farmers in each of the four populations was estimated as a proportion of the land area included in the study. Non-farm portions of counties (e.g., urban areas and lakes) were excluded for the purposes of these estimates.

Initially, sample sizes for the four populations were calculated using statistical methods (Snedecor and Cochran 1967; Lipsey 1990; Henry 1990). Population sizes varied between the northern area and the southern area. We attempted to control sampling error across the four populations. A conservative sampling error of 0.04 was used to calculate initial sample sizes for each population. Probability of farmers being affected

by the atrazine guidelines to some degree was set at a conservative p = 0.5 or 50 percent:

Error = sqrt ((1-n/N) * ((p*(1-p))/(n-1))) @ p(0.5)

n = sample size N = population size

Once overall sample sizes for each of the four populations were determined, they were increased to account for an expected final 60 percent response rate from the surveyed farmers. Using these parameters, it was determined that a minimum of 900 surveys would need to be sent. We hypothesized an expected return of 40 percent from the first survey mailout based upon past responses to similar mail surveys. For the 900 farmers sampled:

900 + (900 * 0.6) = 1440 surveys
1st mailout 2nd mailout

Table 5. Population sizes, sample sizes, and area sampled.

Population Area	Estimated population	Sample size	Sq. miles sampled
Southern AMA's			
Columbia	205	42	75
Dane	1415	287	449
Green	162	39	57
Lafayette	436	89	168
Total	**2218**	**457**	**749**
Southern controls			
Columbia	205	42	75
Dane	903	186	291
Green	171	29	60
Lafayette	416	85	160
Rock	496	101	185
Total	**2191**	**443**	**771**
Northern AMA			
St.Croix	408	83	134
Northern control			
St.Croix	386	79	127
Grand Total	5203	1062	1781

Therefore, a minimum of 1440 surveys needed to be printed for distribution.

This research project addressed what is thought by some to be a controversial topic during a period of heavy publicity about atrazine. Corn farmers would also be preparing for harvest at the time of survey distribution. It was assumed both of these factors would reduce expected response rates. Because of these factors, we decided to increase the number of surveys we would send to the maximum affordable. This decision increased the sample sizes above the level required to achieve a sampling error of .04. Ultimately, 1700 surveys were printed. Because the sample size was increased to account for the circumstances described above, the original sample size calculations were inflated to distribute the anticipated "extra" responses.

The above calculations and assumptions made 1700 surveys available for working with four populations (AMA's and controls in the north and south). The number of surveys to print and mail to respondents within each population was determined as per the following example using Columbia County:

$$\frac{\text{(Columbia AMA pop + Columbia control pop)}}{\text{(Total pop of 4 populations)}} * \text{(1700 surveys printed)}$$

$$= \frac{(205 + 205)}{5203} * (1700) = 134 \text{ Columbia County surveys printed}$$

To utilize the 134 surveys over two separate mailings with a 40 percent response from the initial mailout:

(1st mailout) + (1st mailout * 0.6) = 134 surveys

1.6 mailouts = 134 surveys

1st mailout = number of farmers to survey = 84 surveys

Since the size of the control area and AMA area were nearly identical, both at 75 square miles:

(0.5 total sampled area) * 84 surveys = 42 farmers

were sent surveys in both the Columbia AMA and in the Columbia Control.

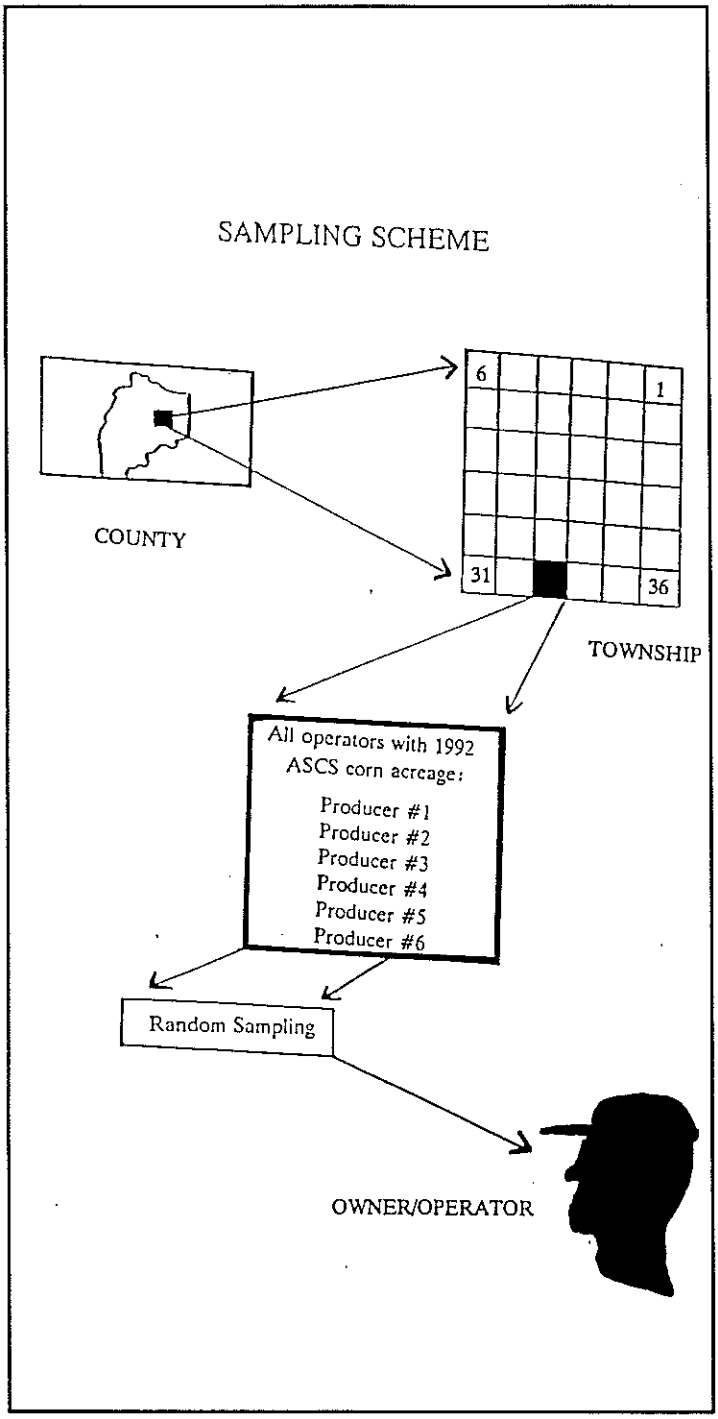


Figure 4. Sampling procedure.

Using this method which utilized 1700 printed surveys, the number of farmers who were sent surveys increased from the initial calculations of 900 to 1062 farmers. The distribution of the 1062 surveys is described in Table 5.

SAMPLING PROCEDURES

The first step in sampling involved obtaining lists of the names and addresses of the populations under consideration (i.e., lists of all corn farmers in the AMA and designated control areas). Excellent cooperation was received from the ASCS state and applicable county offices. ASCS data files were organized by township, range and section. All farmers who were listed as having corn acres in a 1992 ASCS program and whose addresses fell into an AMA or control area section were enumerated (see Figure 4). The following steps were used by ASCS in this process:

1) Look in the "1992 Reported Corn Acreage File" for the geographic areas specified on our list to find all tract numbers on the list.

2) Go to the "Tract File", find the tract numbers from above. The tract file provides a description of the tract, and specifies the farm number that is tied to each tract.

3) Go to the "Farm Producer File" and by farm number find the operator's social security number.

4) Go to the "Name and Address File" and, using the social security number, find the operator's name and address.

After we received the lists of names and addresses, we divided them into two groups -- an AMA group and a control group -- for each county except Rock, which only had a control group. The individual names and addresses were classified as AMA or non-AMA based upon the township, range, and section location of the corn fields designated in the ASCS process. Individuals were then selected from each group using a random selection process (Henry 1990), and the locations were double-checked to ensure that the farmer's land fell into an AMA or control area. The names and addresses were then typed into an Excel spreadsheet and sorted according to name and address to check for redundancies. In cases of redundancy, new names and addresses were added using the same random techniques just described. This process was repeated until all redundancies were eliminated.

SURVEY CONSTRUCTION AND EXECUTION

Survey construction involved designing questions based on research reports, prevailing farm practices and suggestions from the DATCP/ARM Atrazine Technical Committee. The survey instrument is reproduced in Appendix B. Early drafts of the survey instrument were circulated among UW-Madison weed and soil scientists for comment and suggested revision. The UW-Madison Departments of Horticulture and Agronomy were especially helpful on technical dimensions of weed management. The DATCP-ARM staff provided a number of useful suggestions that would provide data to assist them in evaluating the impacts of the Atrazine Rule.

Survey construction and implementation relied on a version of Dillman's "Total Design Method" (TDM). The premise of this method is that "to maximize both the quantity and quality of responses, attention must be given to every detail that might affect response behavior. The Total Design Method relies on a theoretically based view of why people do and do not respond to questionnaires and a well-confirmed belief that attention to administrative details is essential to conducting successful surveys." (Dillman, 1978). The actual design, layout and printing of the survey used desktop publishing procedures while incorporating several four-color graphics and photos. The strategy, as advocated by Dillman, was to create an eye-appealing layout that would improve readability for the farmer. Staff in the UW-Madison Nutrient and Pest Management program assisted with some of the technical components of this work. The survey had a color cover, an inside page that had been constructed from color slides, and a foldout back cover that showed a map on which respondents spatially located their weediest field, primary agrichemical dealer, and residence. Six different surveys were printed. The only difference between surveys was the area depicted on the foldout map. Each map portrayed the designated county as well as adjacent townships. Adjacent townships were included to identify locations of features in those cases in which a respondent lived, purchased agrichemical supplies/services, or farmed in these areas.

The mailing procedure was modeled after Dillman's TDM recommendations. Although Dillman recommended disseminating four personalized and carefully-spaced mailings, we expanded this to five mailings. An advance letter was sent to all respondents explaining the purpose of the survey, the importance of the issue, and how they were randomly selected. This was followed by a cover letter and survey a week later. This mailing occurred on September 2, 1992. A reminder letter was sent to non-respondents on September 25 asking them to please complete the survey as soon as possible. A second copy of the questionnaire with an additional cover letter was mailed on October 14. A final reminder letter with a postcard was mailed on November 12. The purpose of the postcard was to assess reasons for non-response and to informally test for non-response bias. The pre-addressed, stamped postcard listed a variety of potential explanations for not completing and returning the questionaire. Non-respondents were asked to check all relevant explanations and return the postcard by mail.

Throughout this process special attention was given to the minor, yet important, details. These involved genuine signature of all letters, use of colorful, commemorative stamps, selection of envelopes that had a cellophane window showing the colorful survey cover, use of personal salutations on all correspondence, and printing the names and addresses directly on the envelopes instead of using impersonal labels.

Tracking and Data Entry

Data handling, processing, and archiving procedures were developed based on previous experience with mail surveys. For tracking purposes, a four-digit identification number was printed on each survey. The first step upon receiving a completed survey involved logging receipt into an Excel spreadsheet. The Excel tracking system kept a record of when and if a respondent returned a survey, the date that each piece of mail was dispatched to each respondent, and changes in address or respondent identity. A coding system was devised that indicated the status of each returned survey -- unusable for various reasons or usable -- and the appropriate code was

entered into the spreadsheet. The second step involved coding the geographic information by using several mylar overlays. The third step was the actual data entry. An SPSS (Statistical Package for the Social Sciences) package was used for data entry. All comments written on the survey were entered into a WordPerfect file. The final step was that of verification. Every fifth survey was re-keyed into the SPSS package in order to maintain quality control.

Response Rates

County and overall response rates were calculated according to the following process. The number of ineligible returns (eg. surveys returned from farmers who were not growing corn, who are not presently farming, etc.) was subtracted from the number originally mailed. The resulting number of eligible surveys returned was divided by the overall number mailed (minus the ineligibles) to get the response rate. Table 6 represents number of surveys mailed for each county, disaggregated by AMA or control, the number of ineligible surveys, the number of eligible surveys, and county and final response rates.

A total of 489 post cards were sent to survey non-respondents. 162 were filled out and returned. This proportion represents a response rate of 33 percent. Table 7 contains the response frequencies for each potential explanation for non-response listed on the postcard.

Table 6. Final response rate.

County	AMA/Control	Number sent	Number ineligible	Number returned	Response rate
Columbia	AMA	42	0	32	76.2%
	Control	42	3	23	58.9
Dane	AMA	287	19	150	55.9
	Control	186	10	95	54.0
Green	AMA	41	3	24	63.3
	Control	30	1	16	55.2
Lafayette	AMA	89	2	37	42.5
	Control	85	3	33	40.2
Rock	Control	101	3	43	43.9
St. Croix	AMA	84	8	34	44.7
	Control	79	5	30	40.5
Totals		**1066**	**57**	**517**	**51.3**

Table 7. Frequency of potential explanations for not responding to the survey.

Explanantion for not responding to the survey	Frequency	Percent
I have been very busy and your survey came at the wrong time	64	24%
I do not own, operate, or manage a farm and/or did not grow corn in 1992.	11	4
I did not like the subject matter of this particular survey.	11	4
I do not use atrazine and thought the survey did not apply to my operation.	28	10
I am suspicious of university studies.	25	9
I refuse to fill out surveys.	59	22
I meant to fill out the survey, but never got around to it.	28	10
I will fill out the survey and send it in as soon as possible.	19	7

PART II

Research Results

The data set consists of 520 usable cases. The following analysis represents an aggregation of all farmers responding to the weed management survey. This overview will provide the general context against which specific comparisons can be made. Some AMA and non-AMA comparisons are made in this section. **When differences between AMA and non-AMA situations are reported in this section, they will be boldfaced.**

FARM CHARACTERISTICS

The estimated tillable acreage of land operated, owned or rented, was 386.2 acres. This is significantly larger than the average 221 acres for total farm size as found in the 1987 Census of Wisconsin Agriculture.

Of these tillable acres, an average of 224 acres were in field corn, 41.3 acres in soybeans, 23.8 acres in small grains, 13.6 acres in canning crops, 78.0 acres in alfalfa or hay, 25.0 acres in pasture, and 16.7 acres in the Conservation Reserve Program or some set aside program. **AMA farmers had an average of 233 acres in field corn while non-AMA farmers had 220 acres.**

Respondents had an average corn yield of 127.0 bushels per acre, and 14.8 tons per acre for silage. This compares to the state average of 119.0 bushels per acre and 13.0 tons per acre in 1991. **AMA farmers had an average corn yield of 128 bushels per acre while non-AMA farmers yielded 126 bushels per acre.**

Respondents were given 11 categories of income and asked to select the category that best represents gross farm income for 1992. Only a quarter (25.8%) had a gross farm income of $59,999 or less. Another 11.5 percent fell in the $60,000 to $99,999 range. Approximately two-fifths (37.7%) had a gross farm income in the range of $100,000 to $199,999. Another 9.6 percent were in the $200,000 to $299,999 range, and 14.6 percent had a gross farm income exceeding $300,000 per year. The survey clearly captured the larger commercial farms in Wisconsin to the extent that gross farm income represents this dimension. **Based on the midpoints of the above categories, the average yearly income of an AMA farmer was approximately $146,900, and the average for non-AMA farmers was $138,500.**

Dairy and cash grains were the primary sources of income for these farmers. Just over a quarter (27.1%) said between 80 and 100 percent of their gross farm income was derived from a dairy operation. Another 27.7 percent said between 60 and 79 percent of gross farm income came from dairy. There were 30.1 percent of respondents who said at least 60 percent of their gross farm income came from cash grains. The comparable statistics for livestock was 10.7 percent. Government programs and "other" sources of gross farm income played a minor role in overall farm income. **The average enterprise mix, that is, what percentage of income was derived from various sources, for AMA farmers was 39% dairy, 19.3% livestock, 28.0% cash crops, 7.7% government programs, and 6.0% other. Similarly, the average enterprise mix for non-AMA farmers was 38.9% dairy, 18.3% livestock, 30.0% cash crops, 8.1% government programs, and 5.3% other.**

The respondents had been operating the current farm operation for an average of 22.0 years. Respondents were asked about changes being planned over the next five years. Over ten percent (12.7%) reported that they planned to stop dairying, and another 7.5 percent plan to decrease the size of their dairy operation. This 20.2 percent (stop or decrease) is contrasted with the 8.1 percent who said they were going to start or increase their dairy operation. The majority

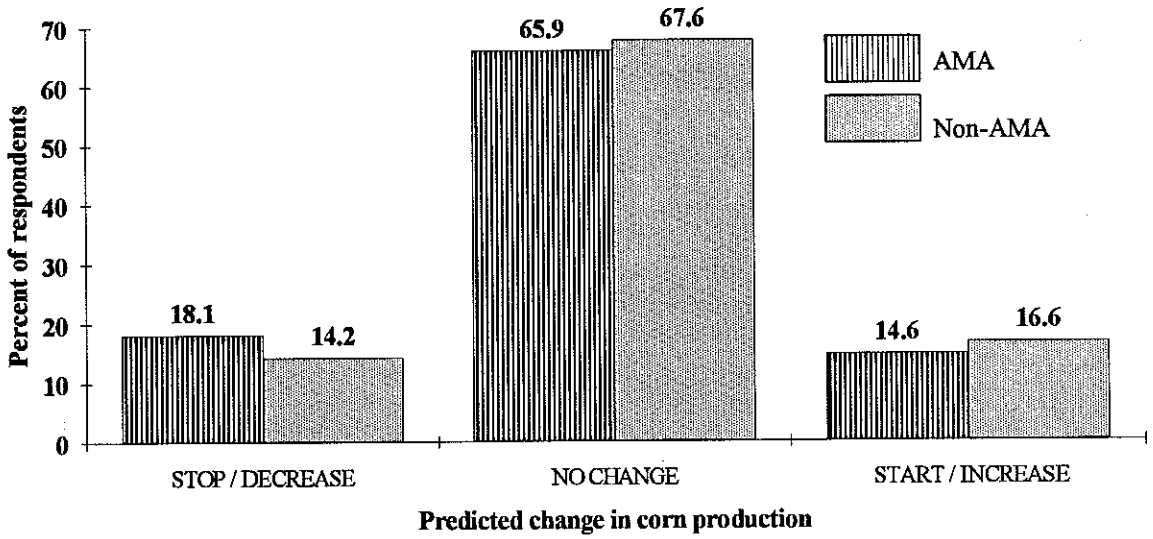


Figure 5. Future corn plans.

(55.0%) are planning to keep their current dairy operation unchanged over the next five years.

Regarding livestock operations, 13.8 percent reported they would stop or decrease such operations, and 22.7 percent intend to start or increase over the next five years. Over half (53.3%) plan to keep current livestock operations the same over the next five years.

In terms of growing corn, 15.9 percent said they would stop growing it or decrease acreage versus 15.3 percent who said they would start growing or increase acreage of corn. Again, the majority (67.1) said current corn operations would remain unchanged over the next five years. **Of non-AMA farmers, 14.2 percent intend to decrease (none said they were going to stop) corn production, and 16.6 percent plan to start or increase. Of AMA farmers, 18.1 plan to decrease acres or stop growing corn while 14.6 percent will start or increase such operations (Fig. 5).**

In terms of growing soybeans, 11.7 percent plan to stop or decrease acres planted, 25.2 percent plan to increase acres planted, and half (45.8%) plan to keep soybean acreage unchanged.

Regarding plans for forage, 15.3 percent plan on decreasing or stopping, and 15.4 percent said forage acres will be increased. The majority (61.0%) said forage acres would remain unchanged over the next five years.

THE WEEDIEST 1992 CORN FIELD

Farmers may manage a number of corn fields in any one year. These fields may be in different rotations or in continuous corn, and can differ significantly in terms of soil and topographic features. It would be difficult if not impossible to capture the complexity of this situation within a single mail questionnaire. That is, attempting to objectively measure the features of the soil, crops, inputs, outputs and pests on any one corn field is in itself a difficult task. Measuring these factors on multiple fields within a farm is a very difficult task.

Consequently, a strategy was devised to focus on a "representative" corn field. At issue was the question: representative of what? A number of alternatives were discussed, e.g., most productive, largest, one in continuous corn, etc. It was decided to focus on the 1992 corn field that the farmer judged to have the most severe weed

problems. Since the objectives of the study concerned atrazine, it was decided to select a situation where the need for atrazine or alternatives would be the greatest. Of course this decision involves certain trade-offs and assumptions. A critical assumption was whether the corn field with the greatest weed problems is representative of other corn fields on the farm. In particular, the question is whether this weediest corn field was managed differently than other corn fields.

A series of management questions were asked to measure how representative this weediest corn field was compared to other corn fields in the farm operation. Respondents were asked if nitrogen, manure, atrazine and non-atrazine herbicide rates on the 1992 weediest corn field were higher, the same or lower than on other corn fields. Table 8 reports the percentages of all respondents who reported higher, same and lower rates for each of these inputs on their weediest field.

The answers of AMA and non-AMA farmers were close to identical on all but one of the above four measures, that being manure applications. Of AMA farmers, 64.1 percent reported applying manure at the same rates on the weediest field, 17.7 percent said higher, and 18.2 percent said lower. In contrast, 70.6 percent of non-AMA farmers used the same rates, only 3.1 percent used higher rates, and only 6.3 percent used lower rates.

Overall, and contrary to the growing trend toward site specific crop management (i.e., responding to differences within a field), the majority of farmers in this study do not differentiate between corn fields relative to inputs. This is strong support for the assumption that the 1992 weediest corn field is representative of all 1992 corn fields within a farm among the overall sample.

Table 8. Inputs on weediest corn field versus other corn fields.

Inputs	Higher	Same	Lower
Nitrogen	3.4%	90.5%	6.1%
Manure	17.5	66.6	15.9
Atrazine	6.5	70.0	23.2
Non-Atrazine Herbicides	20.6	72.7	6.4

Three-quarters (74.7%) of all respondents own the 1992 corn field with the most severe weed problems. The remainder farm the field under some form of a cash rent or crop share arrangement.

This field is an average of 31.9 acres in size with a loam, silt loam, sandy clay loam or silt soil texture group being the dominant type (47.6%). A clay, sandy clay, silty clay, clay loam or silty clay loam is the second most prevalent type (40.9%) of soil texture group on this field.

In terms of corn rotation on this weediest field, 53.5 percent reported it was in field corn in 1990, and 70 percent in field corn in 1991. Of course all the fields were in corn in 1992. Slightly more than half (57.1) said it would be in corn in 1993, and 50.1 percent said it would be in corn in 1994.

PROBLEM WEEDS AND WEED MANAGEMENT

The rank order of five weeds that were targeted for control in 1991 were: 1) velvetleaf (72.1%), 2) foxtail (71.9%), 3) quackgrass (43.4%), 4) lambsquarters (37.7%) and 5) pigweed (31.1%). **The percent of farmers who targeted these same weeds in the AMA and non-AMA sites, respectively, were: 1) velvetleaf (71.6% and 73.2%), 2) foxtail (71.4% and 72.8%), 3) quackgrass (41.1% and 45.9%), 4) lambsquarters (37.9% and 39.1%) and 5) pigweed (29.2% and 34.2%). Slightly, more non-AMA farmers were targeting these five top-ranked weeds than AMA farmers.**

The rank order of the five weeds targeted in 1992 were as follows: 1) foxtail (83.4%), 2) velvetleaf (81.0%), 3) lambsquarters (47.6%), 4) quackgrass (45.0%) and 5) pigweed 38.0%). **The percent of farmers who targeted these same weeds in the AMA and non-AMA sites, respectively, were: 1) velvetleaf (80.3% and 83.2%), 2) foxtail (82.3% and 85.3%), 3) quackgrass (43.5% and 46.5%), 4) lambsquarters (48.6% and 48.6%) and 5) pigweed (38.2% and 40.3%). All farmers were targeting more weeds, but there were no significant differences among targeted weeds for AMA and non-AMA farmers (Fig. 6).**

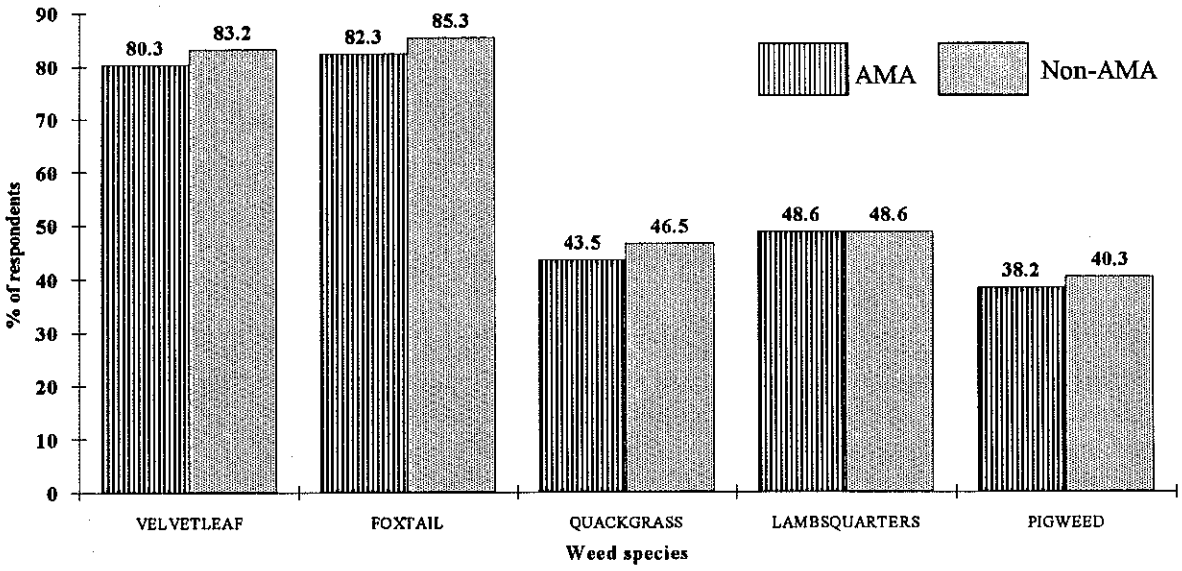


Figure 6. 1992 targeted weeds.

Respondents were asked to rank the top three weeds that gave them the most problems in 1992. Foxtail had 36.7 percent of respondents giving it the number one ranking. Velvetleaf had 19.8 percent saying this was the most problematic weed. No other weed had ten percent or more of the respondents saying it was the worst.

Almost all respondents (92.9%) said they used herbicide to control weeds on this weediest field. **91.4 percent of respondents in AMAs said this, while 94.8% percent in non-AMAs checked this response.** This was followed by 90.3 percent who said they used mechanical cultivation. Just over half (52.3%) said rotation was used to control weeds on this field. **AMA farmers were less likely to check crop rotations (48.0%) than non-AMA farmers (56.6%).** Approximately two-fifths (37.9%) reported using rotary hoeing. Few used the Integrated Pest Management techniques as promoted by UW-Madison (4.5%), a delayed planting date (5.1%), or varietal seed selection with good weed resistance due to fast seeding (canopy) development (3.4%).

Estimating weed pressure on this field is largely one of using informal visual observations (64.5%). Another two-fifths (39.7%) do not formally estimate weed intensity. Instead they regularly apply herbicides as part of growing corn. A quarter (27.8%) rely on a custom applicator or crop consultant for this task. There were 15.3 percent who carried out formal crop/weed scouting according to established procedures. Only 2.0 percent said they established a test (no treatment) plots and compared them against treated portions of the field.

A five-point visual scale of weed intensity was used to estimate weed intensity on this field. The scale ranges between a "1" representing a weed-free situation where it is almost impossible to find a single weed up to a "5" where one has trouble finding the crop as the field may be a total loss. The average weed intensity on the respondent's field in 1992 was 2.9. **Both AMA farmers and non-AMA farmers averaged 2.9 for weed intensity.**

For those who grew corn on this same field last year, the average weed intensity was 2.3 in 1991. **Both the AMA farmer and the non-AMA farmer had an average value of 2.3 for 1991.** In 1992 the highest intensity of weeds on any portion of the field averaged 3.7 on an average of 12.4 acres. **Comparable values for AMA farmers were 3.8 on 13.7 acres while non-AMA farmers averaged 3.8 on 11.6 acres.** Since the average size of this weediest corn field for all respondents was 31.9 acres, another way of interpreting these numbers is to say that 36.8 percent (12.4/31.9) of this field had a weed intensity approaching full weed ground cover.

The yield goal on this weediest corn field for 1992 was an average of 127.4 bushels per acre of

"We stopped using atrazine about five years ago because of damage in alfalfa the following years."

--Survey respondent comment

field corn or 14.8 tons per acre for silage. In 1991 the yield goals were slightly higher for field corn at 130.0 bushels per acre but lower for silage at 12.7 tons per acre. Yield losses from weeds expect to average 28.3 bushels per acre in 1992. The comparable number for silage is 2.8 tons per acre. This compares to 1991 yield losses from weeds of 18.0 bushels per acre and 1.5 tons per acre for silage. Weather patterns in 1992 have significantly increased yield losses due to weeds. **AMA farmers and non-AMA farmers expected similar 1992 yield losses, 29.7 bushels and 28.3 bushels, respectively.**

ATRAZINE USE

Only a quarter (25.8%) of the respondents said this weediest field was not in an Atrazine Management or Prohibition Area. This perception was checked against the location of a check placed on a map contained on the back, inside cover of the mail questionnaire. Respondents were asked to place a check at the approximate location of the weediest corn field on this map. In actuality 52.5% percent of the weediest fields were not in a AMA or APA. This implies that 26.7% percent of the respondents who are not in AMAs or APAs are managing the field as if it were within one of these restricted areas.

There were 56.1 percent who said the field was in an Atrazine Management Area. In actuality, only 42.9 percent of the weediest fields were within the boundaries of an AMA as indicated by the check on the map. Again, this indicates that 13.1 percent of respondents were treating non-AMA fields as if they were within an AMA. There were 12.4 percent who did not know if their weediest corn field was in an Atrazine Management or Prohibition Area.

There were 14.8 percent of AMA farmers who said their weediest field was not in an AMA or APA, an inaccurate belief, and 10.0 percent who did not know if this weediest field was in an AMA or APA. Seven out of ten (69.0%) accurately recognized that this weediest corn field was in an AMA.

For non-AMA farmers, only 34.4% percent accurately recognized that this weediest field was not in an AMA or APA. Another 13.5 percent did not know the status of this field relative to Atrazine Rule boundaries. Slightly less than half (48.3%) of the non-AMA farmers inaccurately believed that their weediest corn field was in an Atrazine Management Area.

Respondents were asked if **any** part of the land they operate was in an Atrazine Management Area (AMA) or Atrazine Prohibition Area (APA). Less than a fifth (20.4%) said none of their land was in an AMA or APA. Over half (59.6%) said part or all of their land was in an AMA, and 9.4 percent said part or all of their land was in an APA. Furthermore, 15.1 percent did not know if any of their land was in an AMA or APA. Of those who said they had land in an AMA or APA, 88.2 percent said part of this land was planted to corn in 1992, and 86.6 percent anticipated part being planted to corn in 1993 or 1994.

Of the 520 respondents, 235 did not use atrazine on their weediest corn field (the study field) while 285 did use atrazine on their weediest corn field. Of those 285 using atrazine, 220 have provided usable rate information (lbs ai/acre/year). The average application rate of atrazine on this weediest field was .88 pounds active ingredient per acre. This ranged between a low of .12 lbs/ac ai up to the high of 3 lbs/ac ai. Forty-five percent of respondents did not apply any atrazine. Of those applying atrazine, 72.5 percent applied one pound of atrazine (active ingredient) or less per acre. Nearly nine-tenths (87.1%) of those applying atrazine applied at 1.5 lbs/ac ai or less. Approximately two percent of all respondents applying atrazine applied at a rate greater than 2 lbs/ac AI. This is in violation of the Atrazine Rule. **AMA farmers applied atrazine on the weediest corn field at an average rate of 0.74 lbs/ac ai while non-AMA farmers averaged 0.98 lbs/ac ai.**

Respondents were asked why they may be using less atrazine now than in past years. A list of possible reasons were given and respondents were instructed to check all answers that apply. Just over half (51.6%) said atrazine restrictions were responsible for lower rates. Half (50.1%) specified problems with carry over into alfalfa or other crops, 38.7 percent cited a shift to more effective non-atrazine herbicides, and 39.2 percent indicated the use of more crop rotations. Environmental reasons such as on-farm ground water pollution concerns were cited by 37.3 percent, and community ground water concerns by 32.1 percent. Just over a quarter (27.7%) cited

increased mechanical cultivation. Only 1.4 percent said they are using less because former corn ground is now in the Conservation Reserve Program or some other set-aside program.

Non-AMA farmers were slightly more likely to cite the use of more crop rotations than were AMA farmers, with respective percentages of 43.8 and 34.9 percent. Non-AMA farmers were also more likely to indicate the use of more effective non-atrazine herbicides as a reason for using less atrazine (43.8%) than were AMA farmers (32.9%). On-farm groundwater pollution concerns and community groundwater pollution concerns were cited by 38.6 and 30.0 percent of AMA farmers, respectively, and by 36.7 and 33.3 percent of non-AMA farmers, respectively. Problems regarding carry over were roughly equal (49.0% of AMA and 52.0% of non-AMA farmers) as were reports of increased mechanical cultivation (30.5% of AMA and 25.4% of non-AMA farmers). However, AMA farmers were more likely to cite atrazine restrictions (61.4%) than were non-AMA farmers (43.3%).

Refer to Figures 7 and 8 for a representation of what atrazine and non-atrazine products were used on the weediest corn field in 1992.

ATRAZINE ALTERNATIVES

A series of questions asked respondents about practices that may be used to reduce reliance on atrazine. These practices were non-atrazine herbicides, reduced herbicide applications, herbicide banding, cultivation, rotary hoeing and weed scouting. Respondents were provided with a short description and then asked about their level of familiarity with each practice. Familiarity was measured on a five-point scale ranging between 5 = fully understand as a local expert, 4 = fully knowledgeable as represented by working knowledge, 3 = knowing a little but lacking working knowledge, 2 = only aware of the practice but lack details, and 1 = completely unaware of the practice. Average familiarity with non-atrazine alternatives was 3.7. With reduced rate herbicide applications it was 3.3, and familiarity with herbicide banding was 2.9. Cultivation and rotary hoeing had a average familiarity rating of 4.2. Formal weed scouting had an average familiarity rating of 3.7.

Current level of use of each practice was measured on a four-point scale where 4 = everywhere possible on my farm, 3 = over many but not all areas on my farm, 2 = trying it on a small area of my farm, and 1 = nowhere on my farm. Non-

Figure 7. Atrazine products used.

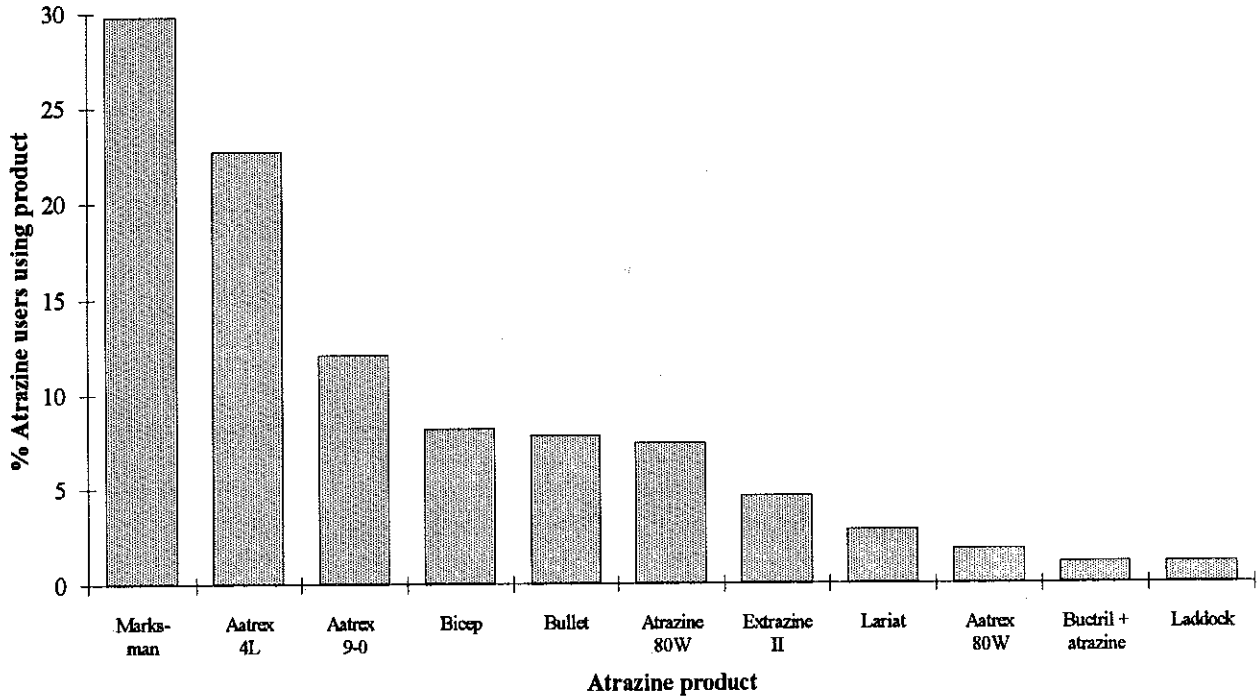
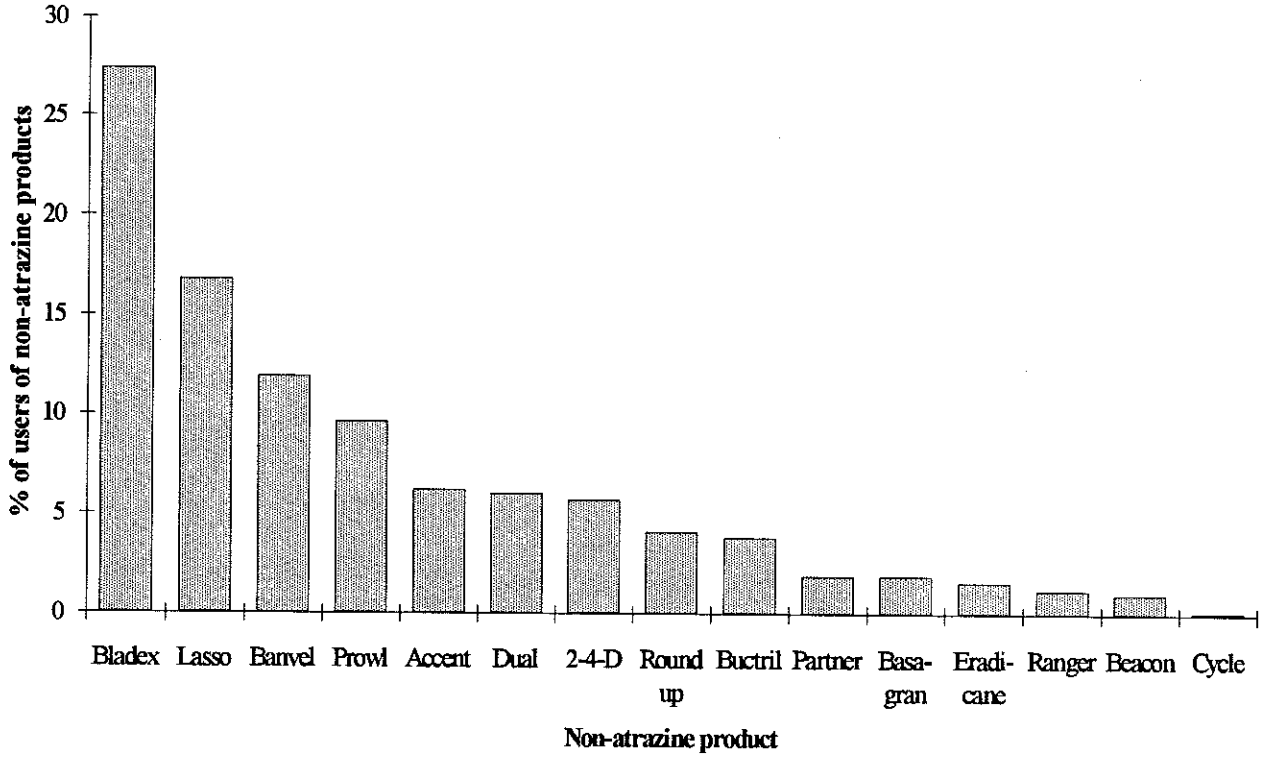


Figure 8. Non-atrazine products used.



atrazine herbicides had an average use rating of 3.1, reduced rate herbicide applications of 2.5, herbicide banding of 1.3, cultivation and rotary hoeing of 3.7, and weed scouting of 3.3.

Past research has demonstrated that perceptions of practices often determine whether a farmer will expend the effort to gather more information, try, or adopt a practice. Respondents were asked about the profitability, labor requirements and risk associated with each of the five practices.

"Outlaw atrazine, we don't need it. We will get it in the water and I mean it."

–Survey respondent comment

Perceived profitability was measured on a five-point scale where 5 = large increase in profits, 4 = small increase in profits, 3 = no change in profits, 2 = small decrease in profits and 1 = large decrease in profits. Non-atrazine herbicides averaged 2.5, reduced rate herbicide application averaged 2.7, herbicide banding averaged 2.8, cultivation and rotary hoeing averaged 3.7 on profitability, and weed scouting averaged 3.7.

Labor requirements for each practice were measured on a four-point scale. The points on this scale were 4 = would require additional workers, 3 = increased demand on current workers, 2 = no change in labor and 1 = less labor required. Non-atrazine herbicides had an average score of 2.3, reduced rate herbicide application averaged 2.4, herbicide banding had an average score of 2.5, cultivation and rotary hoeing averaged 2.8 on labor requirements, and weed scouting averaged 2.5.

The final dimension examined was the perceived risk involved with using these practices. A five point scale was created where 5 = large increase in risks, 4 = small increase in risks, 3 = no change in risk, 2 = small decrease in risks and 1 = large decrease in risk. Non-atrazine herbicides had an average score of 3.4, reduced rate herbicide application averaged 3.7, herbicide banding had an average score of 3.7, cultivation and rotary hoeing averaged 2.9, and weed scouting averaged 2.6.

The averages of AMA and non-AMA farmers for each of the above dimensions – familiarity, use, profitability, labor requirements, and perception of risk – for each practice were essentially identical based on statistical significance tests.

"Don't discontinue atrazine. The cost per acre will increase and weed problems would increase. Atrazine has really helped me to control velvetleaf and foxtail, when put together with Buctril and used post-emergence."

-- Survey respondent comment

GENERAL HERBICIDE USE

Approximately two-fifths (40.8%) all respondents had all herbicides custom applied. Of those who applied some or all of their herbicides, 35.8 percent used a catch container on a test run to calibrate the sprayer. Another 38.8 percent just used last year's setting. Another fifth (22.1%) readjusted the sprayer after spraying the first tank. Another fifth (21.4%) calibrated the sprayer by spraying a test area and then re-filling the tank. There were 12.7 percent who said they visually estimated rates and adjusted ground speeds accordingly. Finally, there were 7.4 percent who calibrated the sprayer by using a hand held or in-line meter. Just over a tenth (12.0%) mentioned some other method of calibrating the sprayer.

Those who applied some or all of their herbicides were asked the frequency of replacing nozzles used for spraying corn herbicides. Just over half (51.5%) said they replaced nozzles based on the number of acres treated. This half said they replaced nozzles after an average of 1053 acres were treated. Another 5.9 percent said they replaced nozzles after an average of 143 hours of use. Just over a quarter (26.0%) said they do not calibrate equipment but rely on experience for proper application. Finally, 18.4 percent who said they did not know how often their sprayer nozzles were replaced.

Those who apply some or all of their corn herbicides were asked the frequency of calibrating sprayer equipment. Just over a half (53.2%) said they calibrate after spraying an average of 216.3 acres. Another 4.1 percent said they calibrate after every 11.3 hours of use. Over a third (35.8%) said they don't calibrate but rely on experience for proper application. A few (6.0%) of the respondents did not know how often they calibrated sprayer equipment.

Only 5.7 percent of the respondents were a Wisconsin Department of Agriculture certified commercial applicator of pesticides. Most (88.6%) said they were certified private applicators of pesticides. A small number (5.4%) said they were not certified to apply pesticides. **Of AMA and non-AMA farmers, respectively, 7.1 and 3.4 percent were certified commercial applicators, 87.1 and 93.1 percent were certified private applicators, and 5.7 and 3.4 percent were not certified.**

Within the past two years just under half (47.0%) of respondents had attended a workshop, field day or education course on sprayer calibration or pesticide application. These were sessions other than applicator certification training. **Slightly more non-AMA farmers (49.7%) attended such an event than did AMA farmers (43.6%).**

ATRAZINE KNOWLEDGE ISSUES

Respondents were asked to assess the accuracy of a series of eight statements related to atrazine use. Respondents were asked if they thought each statement was accurate, not accurate or they did not know the accuracy of the statement. Overall, respondents were able to identify the correct response to 72.5 percent of the questions (5.8 correct out of 8). **AMA farmers correctly assessed 6.0 questions, and non-AMA farmers 5.8.**

The first statement was, "Only a certified applicator can legally apply atrazine." Nearly three-quarters (72.0%) said this was accurate, 23.9 percent said it was inaccurate (a wrong answer), and 4.0 percent did not know the accuracy of the statement.

The second statement was, "Atrazine can be applied anytime during the growing season." Approximately a fifth (22.4%) said this was an accurate statement (a wrong answer), 62.1 percent said it was not accurate, and 11.6 percent did not know the accuracy of the statement.

The third statement was, "Farmers inside atrazine management areas are the only ones subject to atrazine restrictions." There were 16.0 percent who said this was accurate (a wrong answer), 68.3 percent said it was not accurate, and 15.8 percent did not know.

The fourth statement was, "Any person who applies atrazine must keep written records for each application." Nine out of ten (86.5%) of the respondents said this was accurate, 5.4 percent said it was inaccurate (a wrong answer), and 8.1 percent did not know the accuracy of the statement.

The fifth statement was, "Soil texture is an important factor in determining the amount of atrazine that can be legally applied." Again, nine

"There is a big difference in cost if you get control equal to atrazine."

–Survey respondent comment

of ten (88.8%) said this was accurate. There were 6.6 percent who gave the wrong answer by saying it was not accurate, and 4.6 percent did not know.

The lowest level of knowledge occurred on the sixth statement, "Pre-mixed herbicides such as Bicep, Bullet and Lariat contain atrazine." Only two-thirds (65.6%) of the respondents recognized this as an accurate statement. Only 4.3 percent got it wrong. The important result was that 30.1 percent who said they did not know the accuracy of this statement.

The seventh statement was, "Routine calibration of sprayers is necessary to insure that herbicides are applied at the desired rate." Almost all (95.4%) of respondent knew this was accurate, while 2.0 percent said it was not accurate (a wrong answer) and approximately one percent (2.6%) did not know.

The final statement was, "The maximum atrazine application rate of 2 lbs per acre per year is only a suggestion and may be exceeded under certain conditions." There were 16.6 percent who said this was accurate (a wrong answer), 67.5 percent who said it was not accurate, and 15.8 percent who did not know the accuracy of the statement.

Detailed comparisons of AMA and non-AMA respondents on their assessments of each of the above eight statements is contained in Focus Report 3 in the next section.

IMPACTS OF AN ATRAZINE BAN

Respondents were asked about potential impacts if atrazine were banned in Wisconsin. They were asked how seven different aspects of their farm would be impacted (whether the aspects would increase, decrease, stay the same) or if they did not know how they would be impacted.

Few (0.4%) said labor requirements would decrease while the majority (50.3%) said they would remain unchanged. However, another two-fifths (45.7%) said labor requirements would increase under an atrazine ban. Only 3.6 percent could not form an assessment relative to labor requirements.

Again, few (0.2%) said management requirements would decrease under an atrazine ban Two-fifths (38.2%) said they would remain unchanged, and just over half (56.0%) said they would increase. There were 2.1 percent who didn't know.

Two-thirds (67.7%) reported that use of crop rotations would remain unchanged while 28.4 percent said they would increase, and 1.8 percent said they would decrease.

The majority (51.5%) said that an atrazine ban would decrease net farm income. A third (33.1%) said it would be unchanged, and 3.9 percent said it would increase. There were 11.5 percent who didn't know the impact of an atrazine ban on net farm income.

A third (35.4%) said crop yields would decrease while a half (51.1%) said they would remain unchanged. Few (1.6%) said crop yields would increase, and 11.9 percent could not assess the impacts of a ban on crop yields.

The majority (53.6%) said weed pressure would increase under an atrazine ban. Two-fifths (36.2%) said it would be unchanged, and 1.6 percent said weed pressure would decrease. There were 8.5 percent who did not know the impact of an atrazine ban on weed pressure.

Two-thirds (64.6%) said that the cost of weed management would increase with a ban on atrazine. Another fifth (21.9%) said weed management costs would remain unchanged. Of those who said it would increase, the additional cost of weed management under an atrazine ban would average $11.48 per acre of corn. **Non-AMA farmers estimated additional costs at $10.96 per acre while AMA farmers estimated these costs to be $11.86 per acre. Refer to Figure 9 for overall net increases or decreases for AMA and non-AMA farmers.**

FERTILITY AND PESTICIDE MANAGEMENT

A number of fertility management services were identified. Refer to Table 9 for percentages of respondents reporting if each service was available, and if they were using the service if available.

Services associated with the soil testing process were the most popular. At least two-thirds of

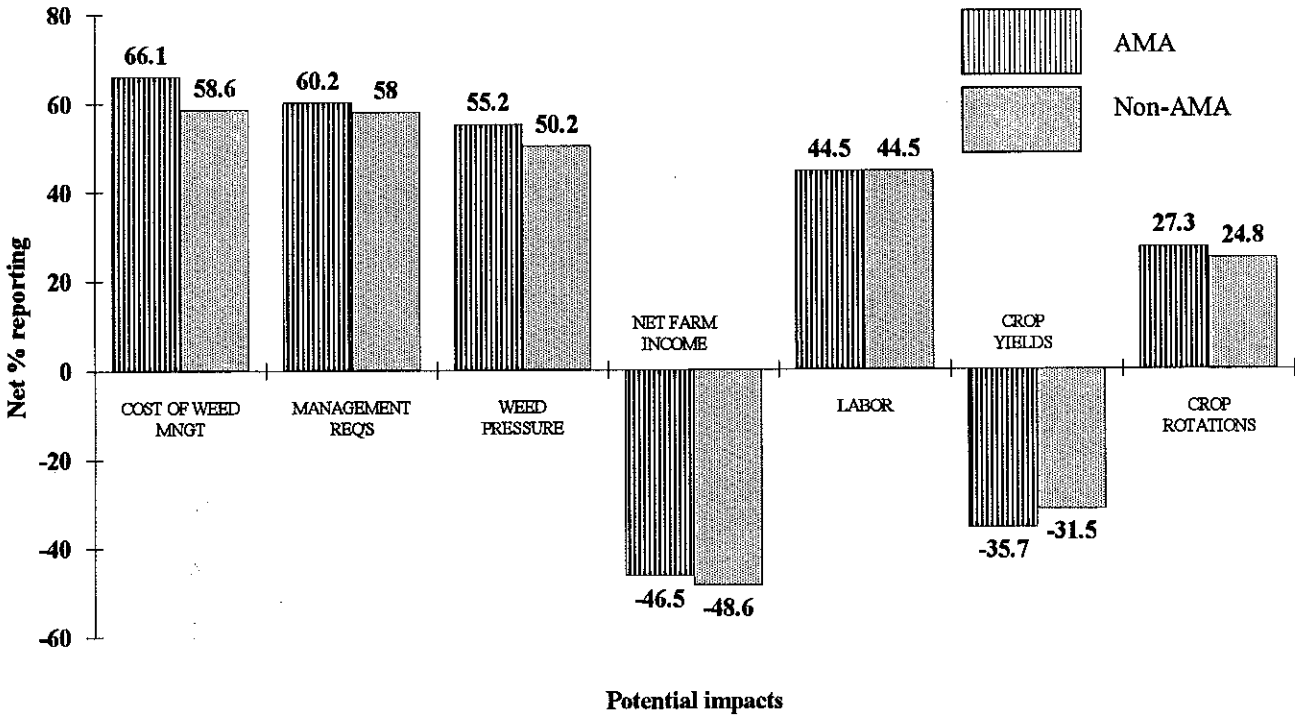


Figure 9. Predicted impacts of an atrazine ban.

all respondents said this organization was taking soil samples, sending them to a lab for analysis, interpreting the findings from the lab, and developing fertilizer recommendations. Approximately another quarter of the respondents said these four services were available, but they were not using them. Record keeping in the sense of tracking what fields received what fertilizers was available and being used by two fifths (42.3%) of the farmers. This was followed by soil fertility mapping (37.8%) and crediting of manures (31.5%). Over half of the respondents did not know if manure analysis, calibration of manure spreaders or sludge application was available from their dealership.

A similar series of questions were asked about insect and/or weed management services. Table 10 illustrates percentages of respondents reporting if each service was available, and if they were using the service when perceived as available.

Again, as in the case of fertility services, there is a clear grouping of services into distinct ranks. Recommending specific pesticide products, the rates associated with a pesticide, and selling the actual product is the dominant activity of these dealerships according to eight of ten of these farmers. Just slightly more than half (56.4%) say that scouting of weeds is available and used. Less than half, but more than two-fifths say that record keeping associated with the Atrazine Rule (48.6%), and custom application of pesticides (43.0%) is available and used. Over half of all farmers say that the following services are either not available or they don't know if they are available; use of computer programs for pest management, field sprayer calibration, weed mapping, rental of pesticide application equipment, or rental of mechanical weeding equipment.

Just under half (46.8%) of the respondents said their primary supplier of agrichemical products and services had encouraged them to apply herbicides at below label recommendations. The remainder (53.2%) said this had never happened.

DEALER RELATIONS

A series of questions were asked about the agrichemical supplier with whom the respondent did the majority of their business in the last year, including the purchase of pesticides, fertilizers and the services related to the use of these products. For a majority (55.4%) of the respondents this represented the cooperative in which they are a member. Another third (36.3%) said this was

Table 9. Availability and use of fertility management services.

Fertility management service	Not available	Available and I am using	Available and I am not using	Don't know if available
Fertilizer recommendations	1.4%	74.1%	23.8%	0.8%
Soil sampling	2.6	69.0	25.2	3.2
Soil testing (lab)	1.4	71.7	23.6	3.2
Soil test recommendations	1.4	69.8	25.4	3.2
Soil fertility mapping	7.8	37.8	24.1	30.4
Plant tissue testing	9.4	10.1	34.7	45.6
Manure analysis	10.9	9.4	25.5	53.9
Manure crediting	6.6	31.5	25.3	36.5
Calibration of manure spreaders	22.2	3.8	13.8	59.8
Sludge handling and/or applicator	35.6	1.5	8.5	53.8
Custom application of fertilizers	2.6	62.2	32.1	2.4
Record keeping	7.5	42.3	19.9	30.0

Table 10. Availability and use of pesticide management services.

Insect and/or weed management service	Not available	Available and I am using	Available and I am not using	Don't know if available
Sells pesticides	0.8%	87.5%	10.5%	1.2%
Rents pesticide application equipment	28.8	7.8	29.0	34.8
Rents mechanical weeding equipment	51.3	3.3	13.9	31.5
Recommends pesticide products	0.4	81.2	15.0	3.2
Recommends pesticide rates	0.8	81.4	13.7	3.8
Scouting (routine)	11.3	22.2	42.9	23.4
Scouting (occasional)	4.3	56.4	24.5	14.3
Weed mapping	14.7	10.7	24.0	50.0
Crop rotation advice	6.5	30.4	31.8	31.2
Field sprayer calibration	12.5	19.3	26.9	41.3
Planter calibration for insecticides	8.8	36.1	21.0	33.9
Custom application of pesticides	3.5	43.0	40.9	12.0
Computer programs for pest management	10.5	8.5	23.1	57.9
Record keeping as required by Atrazine Rule	2.9	48.6	19.4	28.8

represented by an independent agrichemical dealer that was not part of a cooperative. There were 6.3 percent who made the majority of their purchases from a cooperative to which they did not belong, and 1.4 percent identified a crop consultant or farm management service. On average, respondents spent 91.1 percent of expenditures for agrichemical products and services with this same organization. Respondents had been dealing with this organization for an average of 14.5 years.

Learning about the needs and requirements of the respondent's farm operation was largely based on interpersonal communication. Two-thirds (68.7%) said this happened with farm visits, and another two-thirds (63.8%) reported over-the-counter discussions. Telephone conversations were reported by another 57.1 percent as another principal mechanism to learn of client's needs and requirements. Casual social contact was also reported by 35.6 percent as a means to gather this information. Few, however, reported other possible sources such as county agricultural offices (9.4%) or mail surveys (5.5%). Only a small minority (6.3%) of farmers said their supplier doesn't know much about the respondent's farm operation.

Respondents were given a list of possible reasons why they continue to work with their primary supplier of agrichemical products and services. They were intructed to check only three of the potential 13 reasons. The most important, identified by 50.6 percent, was that the dealer offered products and services at a competitive price. This was followed by 43.8 percent who said the dealer offered quality products that have worked in the past. There were 38.5 percent of the respondents who checked the reason that the dealer offered information that could be trusted. Another third (32.9%) said the dealer provides just what the respondent asks for and does not try to push unwanted products or services. Other reasons garnering at least a fifth of the checks were assisting in the identification of weeds and other pests (27.4%), and a willingness to come to the farm to get detailed information on a pest or nutrient problem (20.0%).

Less important, but still receiving at least ten percent of the checks were: helping understand and meet the requirements of various pesticide laws and restrictions (18.5%), proximity or being the closest to the respondent's farm (16.9%), providing a reliable source of information on crop production (16.7%), and knowing the people at the dealership most of their life (14.7%).

Reasons receiving less than ten percent of the responses were: offers new products and services to be tried on the farm (9.5%), helps credit on-farm nutrient sources so that unnecessary fertilizer is not purchased (5.4%), and the dealer provides an annual rebate check based on the amount purchased (2.6%).

Respondents were asked about the amount of information provided by the dealer.They wereasked to indicate whether the dealer provided a great deal, a fair amount, a little or no information on each of six topics (see Table 11). All of these topics are directly related to the Atrazine Rule.

Table 11 indicates that agrichemical dealers were a major source of information relative to atrazine regulations. At least a third of the farmers said their dealers provided a great deal of information relative to responsibilities, maxi-

Table 11. Amount of information provided by the dealer.

	Amount of information			
Topics	**Great deal**	**Fair amount**	**A little**	**None**
Responsibilities under the Atrazine Rule	34.2%	39.3%	15.2%	11.3%
Pesticide handling, loading, storage, and disposal	27.1	41.5	31.5	12.7
Non-atrazine herbicides	32.9	46.1	13.2	7.9
Mechanical weed control	13.8	29.6	28.0	28.6
Record keeping requirements under the atrazine rule	24.4	31.0	21.7	20.0
Maximum allowable atrazine application rates	38.8	35.5	12.9	12.7

mum allowable rates, and the use of non-atrazine herbicides. Few (13.8%), however, received much information regarding different forms of mechanical tillage.

WATER QUALITY ISSUES

Just about all respondents (97.8%) rely on a private well as their primary source for household water. Almost half of the respondents test this household water source for nitrates (49.9%) and bacteria (44.0%) at least once a year, and 29.9 percent had installed a back-siphon prevention device on this water source. Another fifth (20.2%) said they test for pesticides at least once a year. Very few use a home water treatment system (3.6%) or rely on bottled water as the source of drinking water (0.5%).

Respondents were asked to evaluate the quality of their drinking water on a five-point scale. This scale varied between a -2 representing very poor quality up to a +2 representing excellent water quality. The majority (54.5%) of the respondents rated their drinking water excellent (+2). Another third (32.0%) gave it a +1 rating. A tenth (12.1%) gave it a 0 rating while very few gave it a -1 (1.2%) or a -2 (0.2%) rating. The average water quality rating was 1.4. **The average water quality rating of both AMA and non-AMA farmers was also 1.4.**

Respondents were also asked to assess how the quality of this drinking water has changed over the last five years. Again, a five-point scale was used where +2 = "much better," +1 = "better," 0 = "no change," -1 = "worse," and -2 = "much worse". The majority (90.7%) said therewas no change (0) in the quality of their drinking water in the last five years. More said it improved (+1 = 3.8% and +2 = 2.4%) than said that it worsened (-1 = 2.4% and -2 = 0.8%). The overall average rating was 0.1. **The ratings of AMA respondents averaged 0.0 while those of non-AMA respondents averaged 0.1.**

Respondents were asked to project five years into the future regarding the quality of their drinking water. The same five-point scale used in the previous question was repeated. The majority (79.2%) said they expected no change (0) in their drinking water quality. Less than ten percent (7.6%) said it would improve somewhat (+1), and 3.2 percent who expected it to get much better (+2). On the other end of the spectrum, 9.0 percent expected a slight decrease (-1) in the quality of drinking water, and only 1.0 percent said it would get much worse (-2). The average rating was 0.1. **Again, the ratings of AMA and non-AMA farmers were nearly identical, 0.0 and 0.1, respectively.**

The next series of questions asked about the location and characteristics of the site usually used for loading atrazine into a field sprayer. A quarter (25.1%) said this occurred off-farm at a dealer or custom applicator's facilities. A third (34.9%) reported that it was in the field that was going to be sprayed. Two-fifths (40.0%) said atrazine was usually loaded at their farmstead.

Of those loading atrazine on their farmstead, 86.0 percent said the location was greater than 50 feet from the well that serves as the primary source of drinking water.

Those loading atrazine on-farm (field or farmstead) were asked about the surface of this loading site. Two-fifths (41.3%) said it was dirt or grass, 39.1 percent said it was gravel or crushed rock, 12.1 percent said it was concrete, and 7.5 percent said the loading site was surfaced with blacktop or asphalt.

PART III

Focus Report 1

The Agronomic Impacts of the Atrazine Rule

This report presents the research findings related to the use of atrazine and how use has changed as a result of the Atrazine Rule. Specific information regarding current and future application of non-atrazine weed management alternatives is presented in **Focus Report 2**, *Status of Non-Atrazine Alternatives.*

A critical objective of this project was to document how corn production changed as a result of the Atrazine Rule. These changes are assumed to be best analyzed at the level of individual farm fields. Additionally, it was anticipated that wider agronomic impacts could be identified through analysis of data collected at the level of the whole farm. Because no reliable baseline data exists to measure how the statewide restrictions impacted growers relative to previous years, the choice was made to compare agronomic management not over time (i.e., pre-Atrazine Rule versus post-Atrazine Rule), but across levels of restriction in a single year; namely, AMA versus non-AMA settings.

The primary advantage of this approach for impact assessment is the fact that it is possible to make statements based on empirical findings after only one growing season. In this situation, where the regulations are evolving at a very rapid pace, and decision makers and critics require a measure of feedback, such fast turn-around has obvious advantages. As mentioned elsewhere in this report, however, policy analysis based on data representing immediate reactions to a new set of rules may not register those impacts that do not manifest themselves quickly. Impacts associated with a time lag may exist undetected due to the timing and design of this analysis.

These data provide three important types of information regarding the agronomic impacts of the Atrazine Rule. First, it is possible to analyze current weed management strategies and assess the relative popularity of atrazine in relation to non-atrazine alternatives. Second, the fact that the 1993 statewide maximum atrazine application rates are the same as the 1992 AMA rates makes it possible to use this data to develop estimates of how the 1993 Atrazine Rule will perform. It is important to keep in mind, however, that the data reported here are based on a regional sampling frame. A statewide sampling frame was not constructed. Third, based on field level data combined with secondary sources of information, it is possible to evaluate the Atrazine Rule's potential for initializing significant changes in Wisconsin's agriculture.

Analysis of the application of a specific agricultural practice must be considered in the context of a farming system. The individual components of an agronomic management strategy, when taken out of the context of the farming system, lose much of their significance. For example, comparing application rates of atrazine between two specific fields, without controlling for crop rotation, does not provide a particularly useful measure of the constraints atrazine regulations impose. For this reason, findings reported here represent parallel field management situations. The comparisons are based on the aggregation of those cases where there are sufficient similarities in regard to the subject of interest. It should be noted that this approach is limited by sample size as the number of qualifying statements applied to screen out cases causes the number of eligible cases to decline rapidly. In general, the variable used most consistently to aggregate cases is crop rotation. Other qualifying parameters are applied as appropriate.

In order to maintain sub-samples large enough to measure differences across levels of restriction (level of restriction refers to AMA or non-AMA status of a particular field), while controlling for rotation, each reported crop rotation was fit to one of four categories. Because atrazine "carry-

Table 12. Crop rotations in samples (percents).

	Continuous corn	1st year corn	Other	Last year corn
AMA	41.7	17.2	16.2	25.0
Non-AMA	29.4	17.9	18.7	34.1

over" is known to be a consideration in settings where an atrazine sensitive crop follows corn in rotation, potential carry-over was used as the basis of the four rotation descriptions. Carry-over refers to the situation where a percentage of the herbicidal active ingredient remains active in the soil during the next growing season. Crop damage in years following heavy atrazine applications has been widely reported and precautions are explicitly stated on the product label. On this basis the selected rotation categories were 1) **continuous corn**, as defined by a field planted to corn in at least 1991, 1992, and 1993; 2) **first year corn**, as defined by a non-corn crop in 1991 followed by corn in 1992 and again in 1993; 3) **last year corn**, as defined by corn in at least 1991 and 1992, but not in corn in 1993; and 4) **other**, as defined by no second year corn, or in other words, corn in 1992, but no corn in either 1991 or 1993.

Table 12 presents the proportions of each rotation category represented in the AMA and non-AMA samples. In general terms, the two sub-samples are comparable. The higher percentage of continuous corn reported in the AMA may be an indication of more intense corn production in these regions. The intensity of corn production in the regions now designated as AMAs may be responsible for the level of atrazine contamination observed in these areas.

Table 13. Use of atrazine and non-atrazine herbicides by AMA and non-AMA respondents.

Type of herbicide	Restriction status	
	AMA	Non-AMA
Straight atrazine only	20.2%	23.1%
Only atrazine mixes	19.3	29.7
Straight and mixes	2.7	2.6
Neither	52.0	39.2

ATRAZINE USAGE PATTERNS

Atrazine is available in several formulations and is readily combined with a large number of other herbicides. Many herbicide combinations can be purchased pre-blended from agrichemical dealers. Additionally, atrazine is suitable for application at many stages of a crop cycle. Fall application is now banned in Wisconsin (Ag. 30), but pre-plant, pre-emergent, post-emergent, and rescue treatment options are available to growers. These variables represent an opportunity for a large number of atrazine application permutations.

Use of a wide variety of herbicides containing atrazine was reported. Figure 10 provides an indication of the most popular products used by respondents. As Figure 10 illustrates, six products account for over 80 percent of the atrazine reportedly applied by respondents.

Three of the six most popular products were "straight" atrazine products. The other three were pre-mixed products. By straight atrazine we mean those products which contain no active ingredients other than atrazine[1]. Use of pre-mixed atrazine herbicides and "straight" atrazine products were reported with roughly equal frequency by AMA and non-AMA respondents, as illustrated in Table 13. Pre-mixed herbicides were slightly less popular in the AMA than in the sampled non-AMA area. This result is somewhat surprising. It was expected that the low rates of active ingredient atrazine in pre-mixes relative to "straight" atrazine products would make these products more attractive to producers operating inside the AMA.

Post-emergent and pre-emergent atrazine applications were observed with similar frequency. Table 14 represents the timing of atrazine applications in the AMA and non-AMA samples. These data indicate that AMA designation does not appear to have altered the timing of application.

[1]Straight atrazine herbicides actually do contain small amounts (2%) of non-atrazine active ingredient. These other active ingredients are labeled as "Related Compounds" on the federal label.

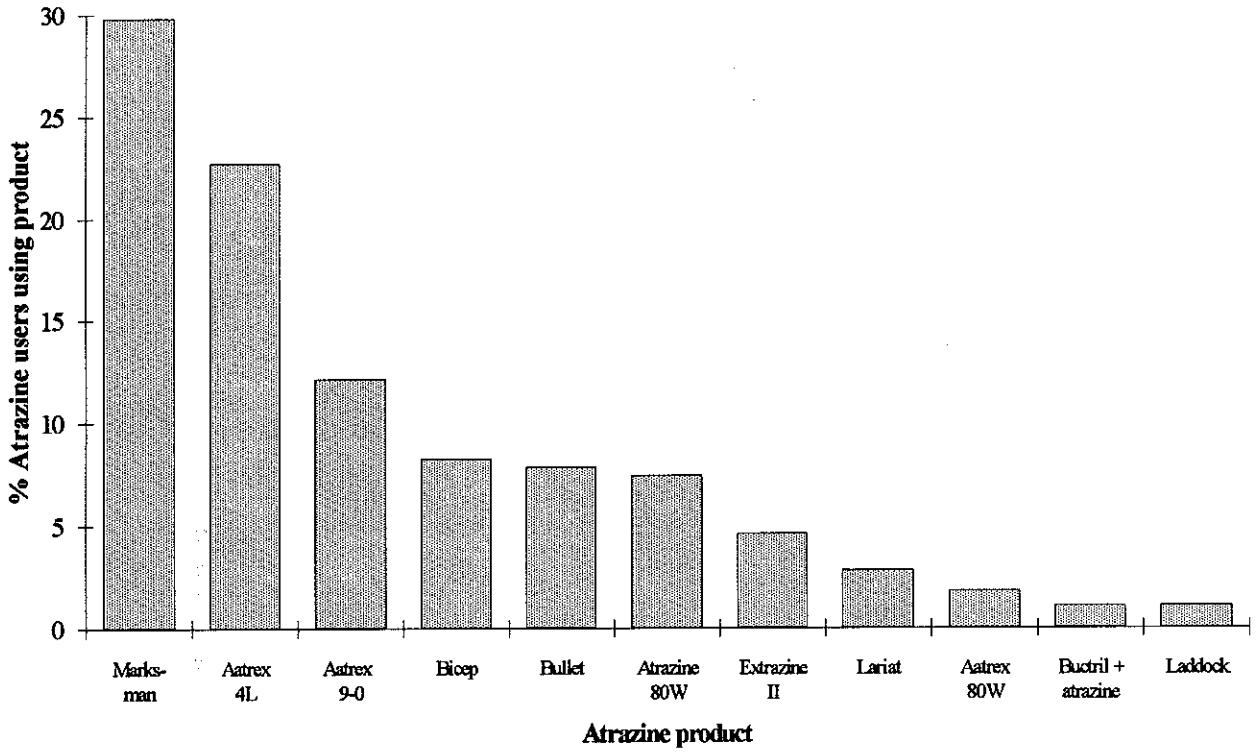


Figure 10. Atrazine products used.

A primary objective of the Atrazine Rule was to differentially reduce the amount of atrazine being applied in the AMA relative to the state as a whole. This objective appears to have been met by reductions as measured by two discrete criteria. The data show both the proportion of acres in the weediest corn fields treated with atrazine and the rates applied to treated acres to be lower in the AMAs than in the non-AMA areas. In other words, the extent and intensity of atrazine use was lower in the AMAs than in the non-AMA areas.

For each of the eleven sub-samples, the percentage of corn acres treated with atrazine in 1992 in the AMAs and the non-AMA areas are presented in Table 15. As Table 15 illustrates, 70 percent of the acres in the weediest corn fields in the non-AMA areas were treated with atrazine. In the AMAs, the comparable statistic was 60 percent. In each county, with the exception of Columbia, the likelihood of a sampled field being treated with atrazine was lower inside an AMA than in the matched non-AMA area. This indicates that the extent of atrazine use was lower inside the AMAs relative to the sampled non-AMA areas.

Table 14. Timing of application by restriction status.

Timing of application	AMA	Non-AMA	Total
Pre-plant	5.0%	2.0%	3.2%
Pre-emergent	40.0	46.9	44.1
Post-emergent	47.0	42.2	44.1
Rescue	8.0	8.8	8.5

An analysis of proportion of respondents reporting use of atrazine on the sampled field yielded similar results. As Table 16 illustrates, AMA respondents were less likely to use atrazine than were their non-AMA counterparts. These data indicate that a non-AMA respondent was 1.68 times as likely as an AMA respondent to report using atrazine on the sampled field. The fact that these percentages are even lower than the acreage figures indicates a significant finding -- larger fields were more likely to be treated with atrazine. For example, in the Columbia County AMA, 38.5 percent of the respondents reported use of atrazine, yet 61 percent of the sampled acreage received atrazine treatment.

Table 15. Percentage of corn acres treated with atrazine in AMA and non-AMA areas.

County	AMA acres treated with atrazine	AMA acres with no atrazine	Non-AMA acres treated with atrazine	Non-AMA acres with no atrazine	% AMA acres treated with atrazine	% Non-AMA acres treated with atrazine
Columbia	643	407	425	388	61%	48%
Dane	1968	1850	1122	2258	51	67
Green	288	195	138	440	60	76
Lafayette	733	209	130	707	78	84
Rock	na*	na*	496	1255	na*	72
St. Croix	721	251	13	523	74	97
Totals	**4353**	**2912**	**2324**	**5571**	**60**	**70**

* Rock County did not contain an AMA. The northwest portion of Rock County served as a control for portions of Dane County.

The average size of sampled fields treated with atrazine was 38.2 acres. The average size of those fields not treated was 24.6 acres. This difference is statistically significant ($p < .01$). Figure 11 illustrates the relationship between a sampled field's size and the likelihood of that field being treated with atrazine. Potentially, the increased cost associated with mechanical control and/or non-atrazine herbicides over larger acreages is responsible for this difference.

As reported earlier, a large degree of confusion exists concerning the regulatory status of the weediest corn field. A majority (55%) of all respondents incorrectly identified the degree to which their use of atrazine was regulated. We define incorrect here as the improper identification of the location of the weediest corn field relative to AMA designation. In order to analyze the influence of this confusion on the reported use of atrazine, respondents who correctly identified their field's status were analyzed apart from those who were mistaken. The results were consistent across the two groups. Fifty seven percent of those who were accurate relative to their field's status applied atrazine as compared to 53 percent applying atrazine while mistaken regarding thier field's AMA status. The difference between these two proportions is not statistically significant. This result indicates that knowledge of the restriction status of a field did not significantly change the relative likelihood of using atrazine on an AMA or non-AMA field.

Table 16. Percentages of respondents in AMAs and non-AMA areas using atrazine.

County	Percent AMA respondents applying atrazine	Percent non-AMA respondents applying atrazine
Columbia	38.5%	36.0%
Dane	44.3	53.4
Green	44.4	61.9
Lafayette	64.3	70.6
Rock	na	60.9
St. Croix	58.6	98.8
Totals	**48.0**	**60.8**

The application rates reported in Table 17 represent a significant accomplishment of the Atrazine Rule. Consistently, the application rates in a AMA were lower than in the matched, non-AMA sample. The overall average application rate in the AMA in 1992 on the acres receiving atrazine was .74 lbs. active ingredient per acre. The comparable statistic for the non-AMA sample was .98 lbs. active ingredient per acre. This is a 25 percent reduction, and the difference is statistically significant ($p < .01$). Figure 12 represents frequency distributions for atrazine application rates reported overall, in the AMAs and in the non-AMA areas.

While the restrictions have influenced some producers to reduce their use (acres treated and rate) of atrazine, the restrictions do not appear to have caused wide-scale abandonment of atrazine. In fact, for each rotation category, in both the AMAs and the non-AMA areas, sizeable proportions of respondents report use of atrazine on their weediest field. Table 18 contains the percentages

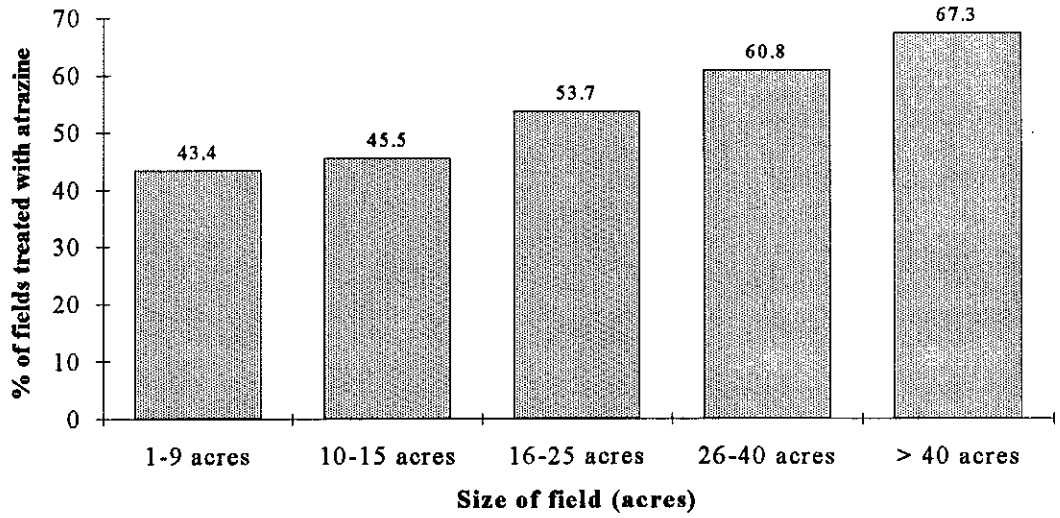


Figure 11. Percentage of fields treated with atrazine by field size (acres).

of respondents using atrazine in each of the four rotation categories in the AMAs and non-AMA areas.

As would be expected, the data shows that fields rotating into atrazine sensitive crops (i.e., last year corn and other) were less likely to be treated with atrazine than those fields remaining in corn. This trend is attributable to the practice of guarding against carry-over despite evidence that carry-over is a negligible agronomic issue due to rate restrictions currently in place (Proust, 1992). Additionally, the formulations represented by popular pre-mixed herbicides, such as Marksman and Lariat, contain reduced amounts of active ingredient atrazine, making carry-over damage even more unlikely. Carry-over, for example, has traditionally been a problem in situations where a late season outbreak of a problem weed, such as quackgrass, received a heavy application of atrazine. Prior to federal label changes made in 1990, recommended application rates in such a situation were 4.0 lbs. ai per acre. Because this type of treatment is no longer legal, atrazine carry-over is of decreasing importance in herbicide selection.

Overall, the percentage of acres treated was 10 percent less in the AMAs than the non-AMA areas (Table 15). Further, the average application rate on these atrazine treated acres was lower in the AMAs by 25 percent (Table 17). While causality is difficult to establish based on cross-sectional research, there is an indication that AMA designation is recognized as a reason for reduced use of atrazine. AMA respondents cited regulatory restriction as a cause of their diminished reliance on atrazine significantly more frequently than did non-AMA respondents (62% as compared to 44%). Regulation has altered behavior with respect to use of atrazine as part of an overall weed management strategy.

Other research supports these reported values for extent and intensity of atrazine application. In 1991, Wisconsin Agricultural Statistics Service (WASS, 1991) reported that 56 percent of the corn acres in the state were treated with atrazine. Based on the 1985 and 1978 figures, 77 percent and 80 percent respectively, a downward trend is observed. The opposite trend has been reported in Iowa where the percentage of acres treated with atrazine rose from 49 percent in 1985 to 61 percent in 1990 (Eckerman, 1993). However, Eckerman also reported that application rates dropped during this same period. Iowa has adopted a package of atrazine restrictions

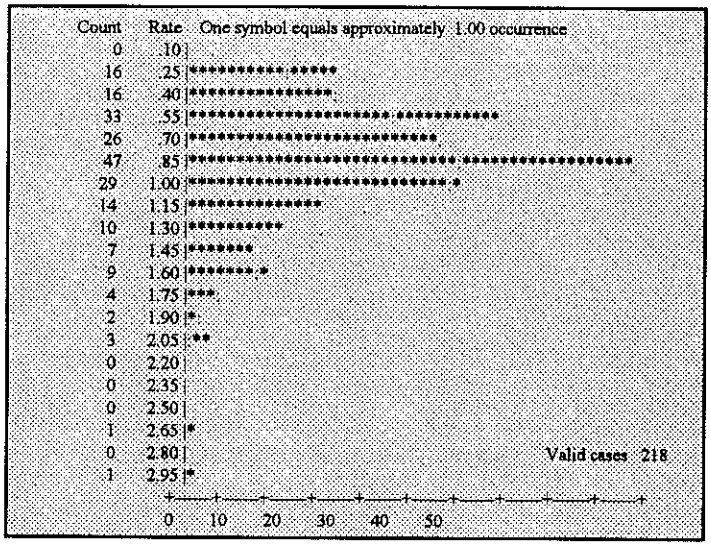
Table 17. Atrazine application rates by rotation (lbs. ai/acre/year).

Status	Rotation based on corn sequence				
	Continuous	1st year	Other	Last year	Total
AMA	0.7**	0.9	0.7*	0.6	0.74**
Non-AMA	1.1**	1.0	1.1*	0.5	0.98**

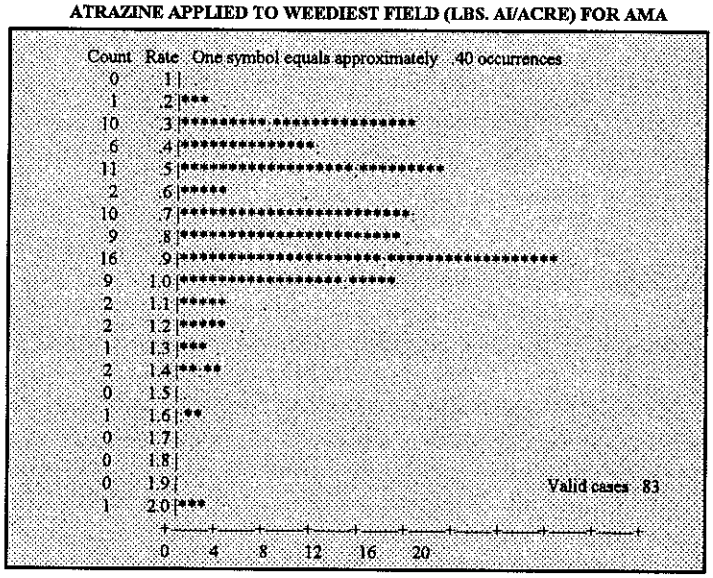
* Significantly different at the 0.05 level

** Significantly different at the 0.01 level

ATRAZINE APPLIED TO WEEDIEST FIELD (LBS. AI/ACRE) FOR ALL RESPONDENTS



ATRAZINE APPLIED TO WEEDIEST FIELD (LBS. AI/ACRE) FOR AMA



ATRAZINE APPLIED TO WEEDIEST FIELD (LBS. AI/ACRE) FOR NON-AMA

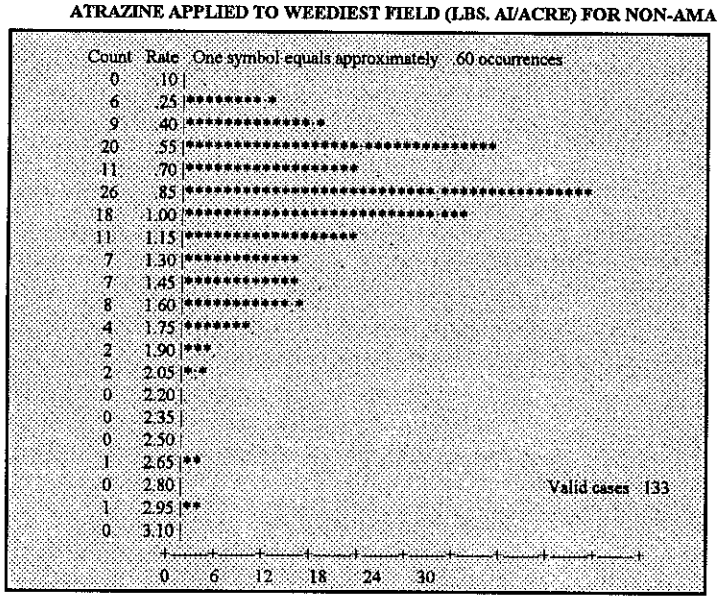


Figure 12. Frequency distributions for atrazine application rates in AMA, non-AMA, and overall sampled areas.

similar to Wisconsin's, beginning in 1990. There is, however, no empirical analysis of Iowa's experience relative to on-farm impacts or success of the regulatory program.

To summarize, the Atrazine Rule has led to a reduction in the proportion of acres treated with atrazine and the rates of atrazine application in the AMAs relative to non-AMA areas. The number of acres treated and the proportion of producers applying atrazine, however, remains significant. The rates reported by AMA and non-AMA respondents indicates there has been a decrease in average atrazine application rate between 1990 and 1992.

THE ROLE OF AGRONOMIC SETTING ON ATRAZINE USE

Because rotation alone does not adequately describe the variability of agronomic conditions which potentially influence atrazine use, it was important to analyze the data along other lines. It is presumed that surface soil texture and organic matter content of a field influence decisions regarding atrazine and the performance of a given application. Additionally, both the weed species requiring treatment and the intensity of weed competition are likely to play a determining role in the use and performance of atrazine. Atrazine use in the sample was analyzed for patterns associated with these agronomic variables.

The relationship of atrazine use to field size was discussed earlier. While larger fields were more likely to be treated with atrazine than were smaller fields, the observed rates of application did not represent a significant difference. No correlation was found between field size and rate of application.

The Atrazine Rule regulates maximum application rates according to surface soil textural class. Due to the characteristically slower "flush" of medium and fine textured soils relative to coarse soils, producers operating on medium and

Table 18. Percentage of respondents using atrazine by rotation.

	Continuous corn	1st year corn	Other	Last year corn
AMA	55.2%	36.1%	50.0%	41.2%
Non-AMA	70.7	70.5	50.0	51.2
Total	62.0	54.3	49.4	46.8

fine textured soils are able to use higher rates of atrazine. Data concerning the soil characteristics was collected relative to the sampled fields. Based on the location of each field in the sample, the soil series for each data point was determined. This was done by locating the position of the weediest field on a soil series map. Results indicate that 90 percent of the soils described by respondents were medium to fine textured. Because the Atrazine Rule is not soil specific beyond textural class, the homogeneity of soil surface textures in the sample makes comparisons made on such a basis impractical.

"I apologize for not knowing if I am in [the] AMA or not. I know my land is not in an APA. I have not used more than 0.75 lb/acre of atrazine for several years to give me rotation freedom."

-- Survey respondent comment

The intensity of weed competition present on the sampled field was measured using a five point scale. Color photographs of varying levels of weed competition were integrated into the survey to provide more consistent measures of infestation. The reported intensity of weed competition was identical, 2.89, by users and non-users of atrazine. The intensity of weed competition was found to be uncorrelated with atrazine use. Of those using atrazine, the application rate was not correlated with intensity of weed competition.

The reported intensity of weed competition was relatively consistent. For the four rotation categories -- continuous corn, first year corn, no second year of corn, and last year corn -- the average weed intensity ratings were 2.97, 2.97, 2.68, 2.89, respectively.

There was little variation between AMA and non-AMA targeted weeds as the percentages of AMA and non-AMA farmers indicating problems with each weed were nearly identical (Table 19). Additionally, the targeted weed species were consistent between 1991 and 1992 on the sampled field. Velvetleaf and Foxtail were the most popular weeds present on the sampled fields in 1992. These two weed species were reported present on over 80 percent of the sampled fields.

Respondents were asked to estimate probable yield loss (bushels per acre) due to weed competition on the weediest corn field for 1992. This anticipated yield loss was found to be negatively correlated with rates of atrazine application ($p<.05$). That is, higher rates of atrazine application are correlated with lower anticipated yield losses.

DISTRIBUTION OF IMPACTS

No unified theory exists to indicate which subset of farms are likely to be disproportionately impacted by a constraint (Stansbury, 1990). In this analysis the constraint of interest is regulation. This issue is important because influences on the structure of Wisconsin agriculture, as defined by the mixture of farm types and scales, are a significant consideration in evaluating the impacts of the Atrazine Rule. Understanding the relative extent to which subsets of farms rely on atrazine allows evaluation of where the difficulty in adjustment lies with respect to current and future restriction of atrazine. The data were analyzed to assess how the required adjustments are distributed across the farm sector.

Overall, farmers reporting more than $40,000 in gross farm income were significantly more likely to use atrazine than were farmers reporting less than $40,000. Farmers deriving less than 60 percent of their income from cash grain production were found to be slightly less likely to use atrazine on the sampled corn field than were those farmers less reliant on grain production.

Table 19. Targeted weed species in AMA and non-AMA areas.

Weed species	AMA	Non-AMA
Velvetleaf	80.3%	83.2%
Foxtail	82.3	85.3
Quackgrass	43.5	46.5
Lambsquarters	48.6	48.6
Pigweed	38.2	40.3

Table 20. Percentage of respondents using atrazine on weediest field by farm size (number of tillable acres).

	1-150 acres	151-250 acres	250-500 acres	> 500 acres
AMA	34.7%	40.0%	50.7%	65.4%
Non-AMA	50.7	60.6	62.9	69.6
Total	44.7	50.0	55.1	67.2

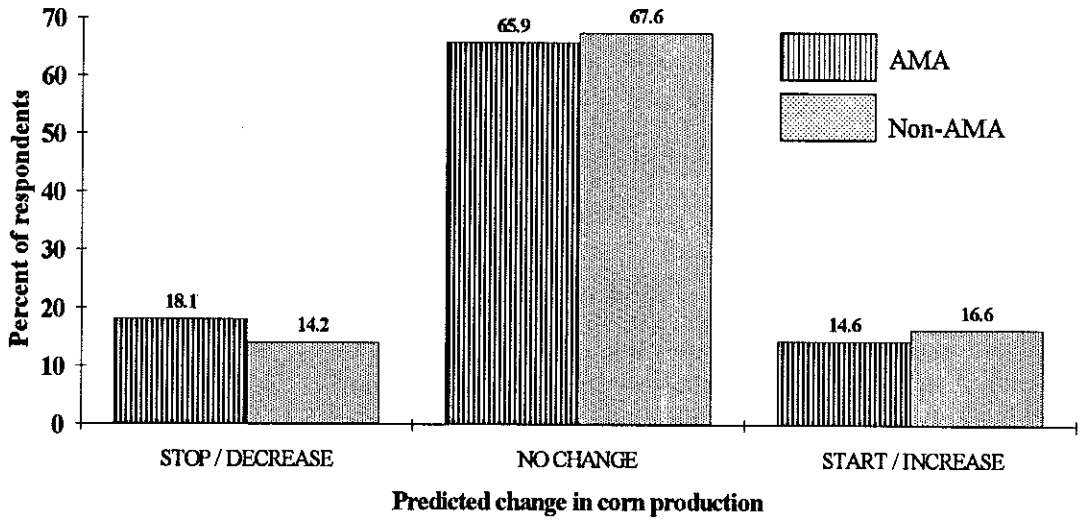
Because the size of a farming operation can be a determinant of what constraints govern field management, the sample was dissagregated by farm size and behavior relative to atrazine use. Reported tillable acres was used to categorize the farms into quartiles; 24 percent of the farms reported less than 150 tillable acres, 25 percent reported 150 to 250 tillable acres, 27 percent reported 250 to 500 tillable acres, and the remaining 24 percent reported over 500 tillable acres.

Farm size based on tillable acres was found to be highly correlated with field size ($p < .01$), i.e., larger farms have larger fields. As noted earlier, field size was correlated with the use of atrazine. As would be expected, the data relating atrazine use to farm size shows a similar pattern, i.e., larger farms are more likely to use atrazine on their weediest corn field (Chi squared= 13.2, df =3). This relationship is displayed in Table 20. The rate of atrazine application, however, does not have a statistical relationship to farm size.

Larger farms offered a lower estimate of the increased cost per acre of weed management in the event of an atrazine ban. The relationship across the four catagories displayed in Table 20 was found to be non-linear. By merging the four farm size categories into two categories, a more useful comparison emerges. Farms reporting over 250 tillable acres estimated an average increase in per acre weed management costs of $13.26. This is a 29 percent increase in estimated cost of weed management under an atrazine ban for smaller farms. This information supports the finding that under an atrazine ban larger farms would have a larger adjustment to make but the cost per acre of that adjustment would be less than that for smaller farms.

Future corn production plans do not appear to have been affected by AMA designation. As Figure 13 illustrates, the net change in predicted production is approximately zero for both the AMAs and non-AMA areas; those planning to decrease or stop growing corn are offset by those who anticipate starting or increasing corn production. These data indicate that AMA designation has not fundamentally altered respondents' anticipated corn production plans.

Figure 13. Future corn plans.



CONCLUSION

This study was conducted during a growing season which featured several late frosts and a very dry start to the growing season. Because most herbicide treatments rely on water to transport and diffuse through the soil, weed control was widely reported to be poor. While these facts may indicate 1992 was not a typical year, the influences of the weather were shared by the producers in the AMAs and their respective non-AMA counterparts.

These data indicate that atrazine use is most frequently observed on larger fields, larger farms, and in situations where corn is grown in multi-year sequences. The Atrazine Rule generated reductions in atrazine use inside the AMA relative to the sampled non-AMA areas. These reductions are substantial, yet atrazine remains widely employed at low rates of application. Based on the documented popularity of low-rate atrazine applications, it is assumed that continued use will occur across a wide range of farming conditions during the 1993 growing season.

Focus Report 2

Adoption of Alternative Weed Management Strategies

As atrazine-based weed management strategies become less popular, alternative techniques and tools will be employed. This report presents an assessment of survey respondents' levels of familiarity, reported usage, and perceptions of several alternative weed management strategies. In order to assess actual and/or perceptual barriers to farmers' adoption of the selected practices, respondents' perceptions were measured relative to the profitability, risk, and intensity of labor requirements associated with each practice.

The alternative weed management techniques analyzed in this study were: *non-atrazine herbicides* -- herbicides that do not contain atrazine; *reduced rate herbicide applications* -- herbicides applied at rates below label directions; *herbicide banding* -- application on planted rows only; *cultivation and rotary hoeing* -- mechanical control of weeds; and *weed scouting* -- visual assessment of weed type and density before deciding on herbicide treatment. These practices were selected for study based on their potential role in farmers' transitions away from atrazine-based weed management strategies.

The familiarity, use, and perceptions of farmers in Atrazine Management Areas (AMAs) and farmers in the matched, non-AMA samples will be compared relative to these alternative practices. Because influences other than AMA status were controlled through the sample matching procedure (see **Part I. Methods** section), differences in familiarity, use, and perceptions relative to alternative weed management techniques can be assumed to be caused by differential atrazine restriction (i.e., AMA designation). This analytic framework was selected because no reliable pre-Atrazine Rule baseline data exists regarding the agronomic practices of interest. In effect, a geographic differential (i.e., inside AMA vs. outside AMA) has been substituted for a temporal differential (i.e., pre-Atrazine Rule vs. post-Atrazine Rule).

The data presented in this report offer a measure of the current status of the selected weed management practices and insight into potential impacts of further atrazine restrictions. In order to investigate possible differences in familiarity, use and perception of these alternative weed management practices by users and non-users of atrazine, comparisons between these two groups will be drawn. In order to assess how farm characteristics may affect familiarity, use and perception of these alternatives, data are examined in relation to a variety of farm and firm characteristics: farm size (tillable acres), percent of gross farm income derived from cash cropping, gross farm income, and extent of involvement with the primary dealer of agricultural chemicals and services.

FAMILIARITY WITH ALTERNATIVE WEED MANAGEMENT PRACTICES

Knowledge is assumed to be a precursor to practice. On this basis, farmers were asked to rate their familiarity with non-atrazine herbicides, reduced rate herbicide applications, herbicide banding, cultivation and rotary hoeing, and weed scouting on a five-point scale. This scale ranged from a "1" (completely unfamiliar) to a "5" (fully understand as a local expert). Respondents were most familiar with cultivation and rotary hoeing (an average of 4.2). This was followed by weed scouting and non-atrazine herbicides, both averaging 3.7. Reduced rate herbicide application averaged 3.3 while herbicide banding averaged 2.9 (Table 21).

Farmers in the AMAs and non-AMA areas had comparable familiarity with each of these practices, as did users and non-users of atrazine. There were no statistically significant differences in any of the ratings. The results of this analysis are presented in Table 21.

Reducing herbicide use is our next management objective. We believe shorter rotations, more alfalfa, and increased mechanical control will facilitate this goal.

-- Survey respondent comment

Table 21. Familiarity with alternatives by restriction status and atrazine use.*

	Restriction Status			Atrazine Use	
Practice	**Overall**	**AMA**	**Non-AMA**	**Used**	**Didn't use**
Non-atrazine herbicide	3.7	3.7	3.7	3.7	3.8
Reduced rate application	3.3	3.3	3.2	3.3	3.3
Herbicide banding	2.9	2.8	2.8	2.9	2.9
Mechanical cultivation	4.2	4.2	4.2	4.2	4.2
Weed scouting	3.7	3.7	3.7	3.7	3.7

*Scale: 1 = Completely unfamiliar; 2 = Only aware, but lack details; 3 = Know a little, but lack working knowledge; 4 = Fairly knowledgeable, have working knowledge; 5 = Fully understand as a local expert.

Significant differences do appear, however, when analyzing the data by size of farm, percent of farming operation in cash cropping, and gross farm income (see Table 22). Farmers with larger farms (tillable acres) were more familiar with each of the practices at a statistically significant level ($p < .01$ for each). Farmers with operations deriving more than 60 percent of gross farm income from cash cropping were more familiar with reduced rate herbicide applications, cultivation and rotary hoeing, and weed scouting ($p < .05$ for each) than were other farmers. Also, farmers with a gross farm income of over $40,000 were more familiar with non-atrazine herbicides, reduced rate applications, banding, and weed scouting ($p < .05$ for each) than were farmers with lower amounts of gross farm income.

An overall measure of familiarity with alternatives was created by adding the responses on each practice and dividing the sum by the number of questions answered. Again, there were no statistically significant differences between AMA and non-AMA farmers nor between atrazine users and non-users relative to overall familiarity with alternative weed management practices. However, as Table 23 illustrates, farmers with larger operations in terms of tillable acres, those with a higher level of gross farm income derived from cash cropping, and those in the higher categories of gross farm income were more familiar with these practices ($p < .05$ for each).

This overall measure of familiarity with alternative weed management practices was also positively correlated with extent of involvement with the primary dealer of agricultural chemicals and services (Table 23). Extent of involvement was calculated by adding the number of services and the amount of information the dealer provided to the farmer. It was found that as involvement with the dealership increases, familiarity with alternative practices also increases ($R = .24$, $p < .01$).

Table 22. Familiarity with alternatives by farm structure variables.

	Gross Income ($)		Farm Size (tillable acres)				Cash crops (%)	
Practice	**<40K**	**>40K**	**<150**	**151-250**	**251-500**	**>500**	**<60%**	**>60%**
Non-atrazine herbicide	3.3**	3.8**	3.4**	3.7**	3.8**	4.0**	3.7	3.9
Reduced rate application	3.1*	3.4*	3.1**	3.2**	3.3**	3.6**	3.3*	3.6*
Herbicide banding	2.5**	2.9**	2.6**	2.8**	2.9**	3.2**	2.8	3.0
Mechanical cultivation	4.1	4.2	4.1**	4.1**	4.3**	4.4**	4.2*	4.3*
Weed scouting	3.4**	3.8**	3.5**	3.6**	3.8**	4.0**	3.6*	3.9*

* Indicates significance at the .05 level.

** Indicates significance at the .001 level.

Table 23. Factors influencing familiarity with alternatives.

Factors	Relationship
Restriction status	No effect
Atrazine use or non-use	No effect
Farm size	Larger farms = greater familiarity
% Cash crops	Higher % cash crop = greater familiarity
Farm income	Higher income = greater familiarity
Involvement with dealer	Greater involvement = greater familiarity
Knowledge of Atrazine Rule	Higher knowledge = greater familiarity

Finally, this overall measure of familiarity was correlated with knowledge of the Atrazine Rule (Table 23). Knowledge was measured using an eight-point scale representing the number of correct responses to eight questions on requirements of the Atrazine Rule. As knowledge of the requirements of the Atrazine Rule increases, so does the overall familiarity with alternative weed management practices ($R = .24$, $p < .01$).

USE OF ALTERNATIVE WEED MANAGEMENT PRACTICES

Use of alternative weed management practices was measured in the same fashion as was familiarity with these practices (Table 24). Farmers were asked to report use based on a five-point scale. This scale ranged from a "1" (using nowhere on my farm) to a "5" (using everywhere possible on my farm). Farmers were most likely to be using cultivation and rotary hoeing, each averaging 3.7 on the five-point scale. This was followed by weed scouting (3.3), non-atrazine herbicides (3.1), reduced rate applications (2.5), and lastly, herbicide banding (1.3). These data share a similar pattern relative to those reported for familiarity.

Analyses were conducted to determine if farmers in the AMAs were using any of these practices to a greater extent than were farmers in the non-AMA areas. The only significant difference was relative to use of non-atrazine herbicides (Table 24). Farmers in the AMAs were more likely to use them ($p < .05$) than were their counterparts in the non-AMA areas. It appears that farmers are responding to the Atrazine Rule's restrictions by using replacement non-atrazine

Table 24. Use of alternatives by restriction status and atrazine use.***

	Restriction Status			Atrazine Use	
Practice	**Overall**	**AMA**	**Non-AMA**	**Used**	**Didn't use**
Non-atrazine herbicide	3.1	3.2*	3.08*	2.9**	3.4**
Reduced rate application	2.5	2.5	2.6	2.7**	2.4**
Herbicide banding	1.3	1.3	1.3	1.2*	1.4*
Mechanical cultivation	3.7	3.6	3.6	3.7	3.7
Weed scouting	3.3	3.3	3.4	3.4	3.3

* Indicates significance at the .05 level.

** Indicates significance at the .001 level.

*** Scale: 1 = Nowhere on my farm; 2 = Trying it on a small area on my farm; 3 = Over many, but not all areas on my farm; 4 = Everywhere possible on my farm.

"In the future, it is my intention to use less herbicides and less insecticides for corn production. I plan to go to shorter rotations ... Also I intend to use minimum and no till practices."

– Survey respondent comment

herbicides. There is no evidence that the Atrazine Rule has significantly accelerated farmers' adoption of non-chemical weed management practices.

A similar analysis was conducted to assess whether users of atrazine use alternatives differently than do non-users of atrazine. Farmers who did not use atrazine on their weediest corn field in 1992 were more likely to use non-atrazine herbicides ($p < .01$) and banding ($p < .05$) than were atrazine users. There were no statistically significant differences between these two groups relative to mechanical cultivation and weed scouting. Non-users, however, were less likely to use reduced rate herbicide applications ($p < .01$) than were atrazine users (Table 24). These data indicate that farmers have substituted herbicide products as an initial coping strategy under the new restrictions.

Use of alternative weed management practices was correlated with the farm and farm firm characteristics used in Table 22. Although farmers with larger farming operations were more familiar with alternative practices, as reported earlier, they were not using any of them to a greater degree. The same pattern holds for gross farm income; there was no correlation between gross farm income and use of each weed management alternative. In regard to percent of farm gross income derived from cash crops, weed scouting was the only practice used more extensively by farms deriving over 60 percent of farm income from cash cropping ($p < .01$).

As was the case with an overall measure of familiarity, an overall measure of use of alternative weed management practices was created. Level of use on each practice was added together and divided by the total number of practices. The analysis found no statistically significant differences between overall level of use of alternative weed management practices relative to AMA and non-AMA farmers, atrazine users and non-users, or among farms of different sizes (see Table 25).

However, the overall measure of use of alternatives did indicate that farmers with more than 60 percent of gross farm income derived from cash cropping were significantly more likely to use these alternative practices ($p < .01$). Overall use of alternative weed management practices and involvement with the dealer was also positively correlated ($R = .20$, $p < .01$). There was no correlation between knowledge of the Atrazine Rule and use of alternatives (Table 25).

PERCEPTIONS OF ALTERNATIVE WEED MANAGEMENT PRACTICES

Farmers were asked to rate each alternative weed management practice relative to profitability, labor requirements, and degree of risk (Table 26). Profitability was measured on a five-point scale ranging between "5" (large increase in profits), to a "3" (no change in profits), to a "1" (large decrease in profits). Overall, farmers rated

Table 25. Factors influencing use of alternatives.

Factors	Relationship
Restriction status	No effect
Atrazine use or non-use	No effect
Farm size	No effect
% Cash crops	Higher % cash crop = greater use
Farm income	No effect
Involvement with dealer	Greater involvement = greater use
Knowledge of Atrazine Rule	No effect

Table 26. Perceptions of profit, labor, and risk associated with alternatives.

Practice	Profit**	Labor*	Risk**
Non-atrazine herbicide	2.5	2.3	3.4
Reduced rate application	2.7	2.4	3.7
Herbicide banding	2.8	2.5	3.7
Mechanical cultivation	3.7	2.8	2.9
Weed scouting	3.7	2.5	2.6

*Scale: 1 = Less labor needed; 2 = No change in labor; 3 = Increased demand on workers; 4 = Would require additional workers.
**Scale: 1 = Large decrease; 2 = Small decrease; 3 = No change; 4 = Small increase; 5 = Large increase.

weed scouting and forms of mechanical cultivation (each averaging 3.7) as the practices that have the greatest potential to increase profits. Farmers rated banding (2.8), reduced rate herbicide applications (2.7), and non-atrazine herbicides (2.5) as practices that would lead to a small decrease in profits.

Even though forms of mechanical cultivation and weed scouting were perceived as profitable, farmers also rated these practices as requiring the most significant labor increases. Labor requirements were measured on a four-point scale: "4" (more labor required), "3" (an increased demand on workers), "2" (no change in labor), and "1" (less labor required). Mechanical cultivation averaged 2.8 on this scale while weed scouting averaged 2.5. The labor requirements of the remaining practices were as follows: non-atrazine herbicides averaged 2.3, reduced rate herbicide applications averaged 2.4, and herbicide banding averaged 2.5.

Risk was measured on a five-point scale ranging from a "5" (large increase in risk), to a "3" (no change in risk over current practices), to a "1" (large decrease in risk). Reduced rate herbicide application and herbicide banding were perceived as having the most risk associated with their use. These practices both averaged 3.7 on the five-point scale. Non-atrazine herbicides, rated at 3.4, were also perceived to increase risk. Mechanical cultivation (averaging 2.9) and weed scouting (averaging 2.6) were perceived as slightly decreasing risk.

Table 27. Perceptions of alternatives by restriction status.

	Restriction Status	
Practice	**AMA**	**Non-AMA**
Non-atrazine herbicide	No difference	No difference
Reduced rate application	No difference	No difference
Herbicide banding	Less labor	More labor
Mechanical cultivation	No difference	No difference
Weed scouting	No difference	No difference

When examining each alternative separately, there are a few statistically significant differences among various farm and user types. The only statistically significant difference between farmers operating in a AMA and those in the non-AMA regions were related to labor costs associated with the practice of herbicide banding. Farmers in the AMAs believe that labor costs for herbicide banding is lower than do their counterparts in the matched, non-AMA regions ($p < .01$). This relationship is summarized in Table 27.

When comparing those who used atrazine on their weediest corn field and those who did not (non-users), non-users rate non-atrazine herbicides, reduced rate applications, and banding as significantly more profitable than do users ($p < .05$ for each). In terms of labor, atrazine users associate significantly greater labor costs with non-atrazine herbicides and reduced rate herbicide applications ($p < .05$ for each) than do non-users. Furthermore, atrazine users associate greater risk with non-atrazine herbicides ($p < .01$). Since farmers who do not use atrazine have already made a switch to non-atrazine weed control practices, it makes sense that they would have these more favorable perceptions. Situations where there are statistically significant differences are summarized in Table 28.

Operators of farms with more tillable acres view herbicide banding and reduced rate herbicide applications to be more risky than do farmers with smaller operations ($p < .01$ and $p < .05$ on each practice). Measures of gross farm income and amount of income derived from cash cropping were not related to perceptions of alternative practices. Farmers' degree of involvement with the primary agrichemical dealer has no significant relation to perceptions of profitability, labor costs, or risk.

An overall index of farmers' perception (prof-

Table 28. Perceptions of alternatives by use of atrazine on weediest field.

	Use of Atrazine on Weediest Field	
Practice	**Users**	**Non-users**
Non-atrazine herbicide	Less profitable More labor More risk	More profitable Less labor Less risk
Reduced rate application	Less profitable More labor	More profitable Less labor
Herbicide banding	Less profitable	More profitable
Mechanical cultivation	No difference	No difference
Weed scouting	No difference	No difference

itability, labor, risk) was created for each alternative weed management practice. A low score on this index indicated a more positive outlook (i.e., high profitability, low labor requirements and low risk) while a high score indicated a more negative outlook (i.e., a large decrease in profits, would require additional workers, and would greatly increase risk).

There were no differences among overall perception between AMA and non-AMA farmers. However, whether or not a farmer used atrazine was related to perception of alternatives: farmers using atrazine have significantly less favorable overall perceptions than do farmers not using atrazine ($p < .01$). See Table 29.

Size of farming operation and perception are positively correlated ($p < .05$); that is, farmers with larger farms had less favorable perceptions. There were no correlations between perceptions and gross farm income, percent of income derived from cash crops, or extent of involvement with the dealer. Perception of alternatives and general knowledge of the Atrazine Rule and related issues were positively correlated ($R = .11$, $p < .05$). See Table 29.

PREDICTED IMPACTS OF AN ATRAZINE BAN

It is logical to assume that farmers' perceptions of the effects of an atrazine ban relate directly to their perceptions regarding alternatives. Farmers who rely heavily on atrazine are likely to be more severely impacted by an atrazine ban than are farmers who rely heavily on alternatives to atrazine. To gauge the perceived impacts of an atrazine ban, farmers were asked to assess how the following factors would be affected by an atrazine ban: labor requirements, management requirements, use of crop rotations, net farm income, crop yields, weed pressure and cost of weed management. They were asked whether such factors would be decreased, unchanged, increased, or that they did not know. To create an aggregate score that reflected the perceived impacts of a ban, the answers were assigned a value based upon the response provided (1 point for a "negative" answer, 2 for "unchanged", 3 points for a "positive" answer), and the values for each factor were summed and divided by the number of questions answered to create a score. A high score

Table 29. Factors influencing perception of alternatives.

Factors	**Relationship**
Restriction status	No effect
Atrazine use or non-use	Users = less favorable perception
Farm size	Larger farms = less favorable perception
% Cash crops	No effect
Farm income	No effect
Involvement with dealer	No effect
Knowledge of Atrazine Rule	Higher knowledge = less favorable perception

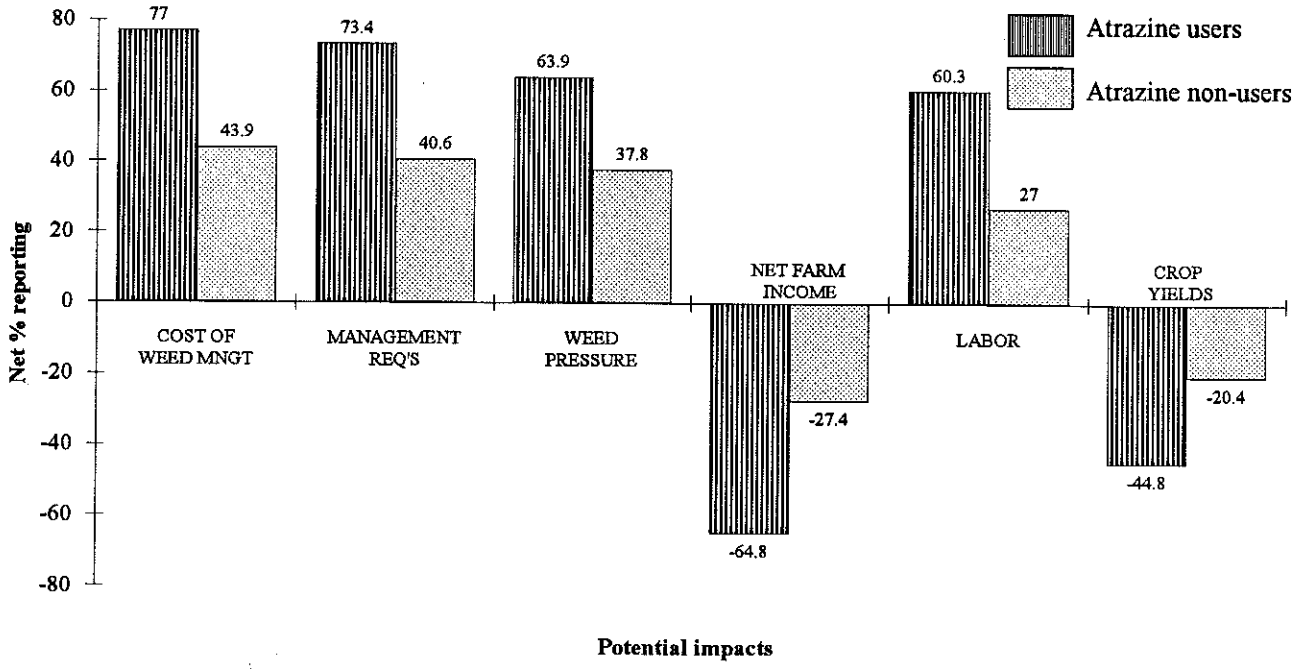


Figure 14. Predicted impacts of an atrazine ban.

indicates positive impacts while a low score indicates negative impacts.

As expected, atrazine non-users were significantly more likely to see positive impacts associated with a ban than were atrazine users ($p < .01$). However, various other comparisons (AMA status, farm size, percent of cash cropping, gross farm income, extent of involvement with the dealer) yielded no significant differences in scores of perceived impacts.

When each of the above possible effects of an atrazine ban were examined separately, there were no differences between the ratings of AMA and non-AMA farmers. However, as Figure 14 illustrates, results indicate that atrazine non-users were significantly more optimistic on each measure ($p < .01$ for each).

PRODUCT SUBSTITUTION

Farmers were asked to indicate their reasons for decreasing use of atrazine if they have indeed reduced their use relative to previous years. Respondents selecting the response "using more effective non-atrazine herbicides" have obviously engaged in product substitution, replacing an atrazine herbicide with a non-atrazine herbicide. While 33.7 percent of AMA farmers selected this response, there were 43.6 percent of non-AMA farmers who also reported it, a significant difference ($p < .01$). This finding indicates that non-AMA respondents attribute their reduction in atrazine use to product substitution more frequently than do AMA respondents (Table 30). Product substitution was identified as a factor in the decision to reduce atrazine applications more frequently by respondents not using atrazine on the sampled field than by those using atrazine on the sampled field (Table 30).

There is also a significant difference between farmers with different levels of gross farm income. Farmers generating more income are more likely to be using non-atrazine herbicides ($p < .05$). There were no significant differences in use of non-atrazine herbicides relative to the total tillable acres or percentage of farm in cash crops. The farm and firm characteristics which are associated with increased likelihood of atrazine use (i.e., large farms, higher income farms, more intense cash grain production) are also associated with higher levels of product substitution. It should be noted, however, that there is only very slim direct evidence of multi-dimensional transition strategies -- those which explicitly involve non-atrazine herbicides and non-chemical weed control practices -- being employed as a result of the Atrazine Rule.

In terms of level of involvement with the dealer, farmers who indicated that they increased

Table 30. Percentages indicating decreased atrazine use to use of non-atrazine herbicides.

Restriction Status		Atrazine Use		Gross Income ($)		Farm Size (tillable acres)				Cash Crop (%)	
AMA	Non-AMA	No	Yes	<40K	>40K	<150	150-250	250-500	>500	<60%	>60%
33.7*	43.6*	35.2*	43.5*	26.6*	40.9*	35.1	34.7	40.3	43.7	37.2	44.0

* Indicates significance at the .05 level.

use of non-atrazine herbicides had a significantly higher degree of involvement with the dealer than did other farmers ($p < .01$). The degree to which agrichemical dealers provide and promote multi-dimensional weed management strategies is being investigated in another study by the authors.

CONCLUSION

Product substitution appears to be the near term response to the Atrazine Rule as supported by two findings: 1) farmers who did not use atrazine on the sampled field were significantly more likely to use non-atrazine herbicides than were atrazine users, and 2) AMA farmers were significantly more likely to use non-atrazine products than were non-AMA farmers. There are indications that multi-dimensional transition egies are beginning to emerge. For a variety of non-atrazine alternatives (non-atrazine herbicides, reduced rate applications, banding, cultivation and rotary hoeing, and weed scouting), across a range of evaluative criteria (risk, profitability and labor requirements), farmers who did not use atrazine consistently reported more favorable opinions than did atrazine users. This result is consistent with research findings regarding the early stages of the adoption process (Rogers, 1983). Findings regarding farm size and the adoption process, however, were inconsistent with literature stating that larger farms are more likely to adopt alternatives. Since larger farms are more familiar with alternatives, however, they may in fact be at the onset of the adoption process. It is likely that these more complex patterns will require several seasons to crystalize.

Focus Report 3

Knowledge and the Atrazine Rule

A major objective of this study was to measure the level of knowledge farmers possess relative to atrazine management. Measuring knowledge is important to an assessment of the Atrazine Rule because it is essential to document farmers' level of understanding of their responsibilities under the Atrazine Rule as well as the areas where knowledge gaps may hinder atrazine management efforts. Clearly, a well-informed farm population is an important component of an agricultural system capable of responding to rapidly evolving technological, political, regulatory, and economic conditions. This report will discuss respondents' knowledge of the Atrazine Rule and related topics.

Knowledge gathering is assumed to be a component of an individual's response to an alteration of the environment. In this case, the alteration is in the form of regulatory restriction. Relative to non-AMA farmers, AMA farmers are expected to have stronger needs for information by virtue of their greater restriction, and they may have more opportunities to collect information (e.g., intensified conversation with peers, Atrazine Rule promotional material from DATCP and agrichemical dealers). Presumably, increased awareness on the part of AMA respondents is assumed to provide an indirect measure of the knowledge gain associated with the Atrazine Rule. Each of the following questions are addressed in this report:

1) Do farmers know their restriction status? That is, do farmers recognize whether or not their land is subject to AMA restrictions or only the statewide-level restrictions?

2) Are farmers violating atrazine rate restrictions (lbs ai/acre/year), indicating a potential lack of knowledge of the Rule?

3) Do farmers know which herbicides contain atrazine?

4) Are farmers aware of specifics of the Atrazine Rule, such as certification requirements, timing restrictions, record-keeping requirements, and the importance of soil texture in determining maximum rate allowances?

5) Do knowledge levels differ across types of farms?

6) Are farmers violating atrazine loading regulations, indicating a lack of knowledge?

KNOWLEDGE OF LEVEL OF RESTRICTION

A major feature of the Atrazine Rule is the designation of three tiers of atrazine use restrictions -- the general statewide restrictions, the AMA restrictions, and the APA restrictions. Logically, farmers must be aware of restrictions applicable to specific fields in order for such a policy to function effectively. In order to assess farmers' knowledge of the restriction status (i.e., statewide, AMA, APA) of their weediest corn field, respondents were asked to report what they believed this field's status to be and to place an "X" on an included map on the location of this field. The location of the "X" as indicated by respondents was interpreted to be accurate at the level of a quarter section. Belief of whether or not a field was in an AMA was verified against the location of the "X" relative to the AMA and APA boundaries. Only four percent of the fields fell in APAs. For the purpose of this analysis, these cases have been excluded.

Results indicate that there is significant confusion regarding AMA designation. While 25.8 percent of all respondents reported that their weediest field **was not** in an Atrazine Management Area, the placement of "X"'s indicated that actually 52.5 percent of the weediest fields were not in an AMA. This implies that 26.7 percent of the non-AMA respondents were possibly managing the field as if it were within an AMA.

Similarly, while 56 percent of all respondents said their weediest field was in an AMA, actually only 42.9 percent of the weediest fields were within the boundaries of an AMA. Again, this implies that a significant percentage (13.1%) of respondents were possibly treating non-AMA fields as if they were in an AMA.

In general, AMA farmers possessed a significantly higher degree of knowledge of field restriction status than did their non-AMA counterparts. Of the farmers sampled within AMA boundaries, 69 percent knew that their weediest field was in an AMA. In comparison, only approximately 35 percent of non-AMA farmers believed that their field was not in an AMA (Table 31).

To summarize, a large number of farmers are operating under misperceptions regarding their restriction status. Some (14.8%) AMA farmers do not realize their weediest field is in an AMA, and almost half (48.3%) of non-AMA farmers incorrectly think their field is in an AMA. Note that the more common error is to over-estimate the stringency of applicable restriction. This indicates that a spill-over effect is occurring whereby AMA designation is impacting farming practices outside the AMAs.

Some of this over-estimation may be due to semantics. Possibly, the statewide restrictions may be interpreted by some to mean that the entire state is an Atrazine Management Area. Regardless, these data indicate widespread confusion regarding the Atrazine Rule.

Because producers operating inside the AMA have been more significantly restricted, they may have obtained more and better information, which may explain their enhanced understanding of the tiered structure of the Atrazine Rule. It could be argued that perhaps AMA farmers are more knowledgeable regarding the status of their fields as a result of educational material targeted specifically to them. The 1993 Atrazine Rule may clear up some of the confusion since AMAs will be eliminated. This change reduces the number of management tiers to two -- statewide restrictions and APAs.

Table 31. Knowledge of restriction status.

	Believe field is in AMA	Believe field is not in AMA	Do not know if field is in AMA
AMA farmers	69.0%	14.8% (incorrect)	10.0%
Non-AMA farmers	48.3 (incorrect)	34.4	13.5

LEVEL OF COMPLIANCE

The restriction status of a field under the 1992 Atrazine Rule dictates the maximum level of atrazine allowed. If there is confusion about the applicable level of restriction, the opportunity arises for non-compliance as a result of ignorance. It is likely that farmers who are violating restrictions and subsequently report these violations through a mail survey are not aware of the law. Based on this assumption, the level of violation provides an indirect indication of knowledge of the Atrazine Rule.

Overall, less than two percent of all farmers were in violation of the 2.0 pound statewide restrictions, indicating widespread knowledge of the law. Only 1.5 percent of non-AMA farmers violated this statewide rate restriction. Although AMA farmers are more aware of their restriction status, as discussed above, they violated rate restrictions to a greater extent than did their non-AMA counterparts. As shown in Table 32 , one in ten (10.6%) of the AMA farmers were in violation of their 1.0 lb./ai/acre rate restriction.

KNOWLEDGE OF ATRAZINE PRODUCTS

An important aspect of farmers' attempts to comply with atrazine restrictions involves their knowledge of products containing atrazine. Atrazine is often sold premixed in combination with other herbicides. Because of the tremendous variety of herbicide products available, and the corresponding diversity of atrazine products, there is concern that some producers are using atrazine and do not recognize it. Such a situation may lead to violation of the Atrazine Rule and may hinder groundwater protection efforts.

Respondents were asked to list the non-atrazine herbicides used on their weediest corn field. By examining the active ingredients of each product reported, it was possible to assess the degree of confusion regarding pre-mixed herbicides. Results indicate that almost all (96%) farm-

Table 32. Violation rates by restriction status.

	Restriction Status	
Atrazine rates	**AMA**	**Non-AMA**
In compliance	89.4%	98.5%
In violation	10.6	1.5

ers who believed they were applying non-atrazine products actually were.

However, when asked to record the atrazine products used on this weediest corn field, there was evidence of confusion. Twenty nine percent of the products that farmers listed as atrazine products actually contained no atrazine. This type of misperception would obviously not lead to violations of atrazine rate restrictions; however, this finding provides an indication of farmers' uneven knowledge of agrichemical products.

In order to assess the degree of confusion regarding premixed atrazine herbicides, respondents' knowledge was probed directly. Although the above findings indicated that almost all (96%) of farmers who believed they were using non-atrazine products were correct in their assumption, a third of the respondents sampled either did not know, or answered incorrectly, when asked if pre-mixed atrazine-based herbicides such as Bicep, Bullet, and Lariat contained atrazine.

"People have gone overboard in using atrazine in previous years. I have always been able to control quack and weeds with 3/4 lbs. per acre of atrazine and 2 lbs. Bladex in first year corn."

-- Survey respondent comment

KNOWLEDGE OF REQUIREMENTS OF THE ATRAZINE RULE

Respondents assessed the accuracy of eight statements related to the Atrazine Rule. Respondents were asked to specify if each of a series of statements was accurate or inaccurate. They also had a third option of indicating that they did not know the accuracy of the statement. The eight statements and the responses are listed in Table 33.

Knowledge varied across topics. Ninety six percent of respondents recognized the importance of routine sprayer calibration to manage atrazine application, while only 62 percent of respondents were aware that atrazine cannot be applied throughout the growing season. Three out of ten respondents did not know if pre-mixed atrazine herbicides such as Bicep, Bullet and Lariat contain atrazine. A quarter (24.0%) of all farmers failed to recognize that certification was required for all persons applying atrazine. Almost nine out of ten farmers (87.0%) realized that written records of atrazine applications must be kept and that surface soil texture is a determining factor for maximum allowable atrazine rates (89.0%).

To summarize, farmers' knowledge of when atrazine can be applied, who is subject to restrictions, what herbicide mixes contain atrazine, and the maximum application rate were relatively weak, with only 60 to 70 percent of farmers correctly assessing statements concerning these issues. Farmers are slightly more aware of certification requirements. Knowledge regarding record-keeping requirements, the importance of soil texture, and the need for routine sprayer calibration is fairly strong, with over 85 percent of respondents correctly assessing statements pertaining to these issues.

The creation of an average "score" of the number of statements which were correctly assessed facilitates comparisons of knowledge across various groups. Two such measures were created: (1) a score consisting of the sum of the number of correct answers (raw score), (2) a score where an accurate answer is awarded a +1, a wrong answer is assessed a -1, and a don't know equals a zero. To calculate this second measure, an individual's points are summed and this total is divided by the number of questions answered.

Overall, according to the first of the knowledge measures, respondents correctly assessed 5.8 out of eight questions. AMA farmers correctly assessed slightly more questions than did non-AMA farmers (6.0 and 5.8, respectively). This difference was not statistically significant. The fourteen respondents who were identified as violating atrazine rate amounts correctly assessed slightly more than the average for all respondents. Although the difference is not significant, the higher than average score of the violators is still surprising.

The second knowledge index (points awarded and penalties assessed) showed no significant differences between AMA and non-AMA farmers; they averaged 0.63 and 0.65, respectively. These data show no knowledge gain associated with AMA designation. This finding

Table 33. Knowledge of issues relating to the Atrazine Rule.

Statement	Accuracy	Group	% incorrect answers	% correct answers	% didn't know
Only a certified applicator can legally apply atrazine.	accurate	Total	24%	72%	4%
		AMA	25	73	2
		Non-AMA	24	71	5
Atrazine can be applied any time during the growing season.	not accurate	Total	22	62	12
		AMA	21	65	14
		Non-AMA	23	62	10
Farmers inside AMAs are the only ones subject to atrazine use restrictions.	not accurate	Total	16	68	16
		AMA	18	66	16
		Non-AMA	15	70	15
Any person who applies atrazine must keep written records for each application.	accurate	Total	5	87	8
		AMA	6	85	9
		Non-AMA	4	89	7
Soil texture is an important factor in the amount of atrazine can be legally applied.	accurate	Total	7	89	5
		AMA	9	87	4
		Non-AMA	4	91	5
Pre-mixed herbicides such as Bicep, Bullet, and Lariat contain atrazine.	accurate	Total	4	66	30
		AMA	4	66	30
		Non-AMA	4	67	30
Routine sprayer calibration is necessary to insure that herbicides are applied at desired rates.	accurate	Total	3	96	3
		AMA	3	94	3
		Non-AMA	1	97	2
The maximum atrazine application rate of 2 lb acre/year is only a suggestion and may be exceeded under certain conditions.	not accurate	Total	17	68	16
		AMA	16	72	13
		Non-AMA	19	64	18

may indicate that AMA respondents did not recognize a need to obtain atrazine management information or that atrazine management information was not readily available.

KNOWLEDGE AND FARM CHARACTERISTICS

Size of farm, percentage of income derived from cash grains, and gross farm income were all positively correlated with knowledge as measured by number of correctly assessed statements (Table 34). As size of farm increases, the number of correctly assessed statements increases ($p<.05$). A comparison of the average number of statements correctly assessed by farmers receiving over sixty percent of their income from cash grains with their counterparts indicated a significant difference ($p <.05$). Farmers receiving over $40,000/year correctly assessed significantly more statements than did farmers receiving less than that amount ($p<.01$).

An examination of the second measure of knowledge also indicated that farm size, gross farm income, and percent of income derived from cash crops are positively correlated with knowledge (Table 34). Whether or not a farmer used atrazine on the weediest corn field did not significantly affect the score.

"Eliminate or restrict atrazine use altogether. We must protect our most important resource, our water supply."

-- Survey respondent comment

KNOWLEDGE OF ATRAZINE LOADING REGULATIONS

Atrazine contamination of groundwater is the result of both non-point source pollution (i.e., field application) and point or quasi-point sources (Hallberg, 1988). Point sources are associated with known sites where contamination has occurred through a spill or leak. Quasi-point sources refer to situations where the density of discrete sites of contamination (i.e., atrazine mixing and loading sites) is so high as to constitute a threat to groundwater across a wide area. Wisconsin law regulates the type of surface (i.e., ground cover) over which atrazine can be loaded into a sprayer or other applicator when the loading site falls within fifty feet of a well which serves as a primary source of drinking water. The law specifies that the surface must be concrete or asphalt. Because violation of these rules may indicate a lack of knowledge of the law, compliance with loading requirements was assessed. Only fourteen percent of the farmers who loaded atrazine in the field or at the farmstead reported that the loading site was within fifty feet of the well that serves as the primary source of drinking water. Of those fourteen percent, however, 23.7 percent report a surface of dirt/grass and 47.4 percent report gravel/crushed rock, surfaces clearly in violation of the Atrazine Rule.

CONCLUSION

In conclusion, farmers' knowledge of the Atrazine Rule is uneven, weak in some areas while strong in others. Knowledge is weak in the areas of restriction status, what products do and do not contain atrazine, and when atrazine can be applied. Knowledge appears to be strong in terms of rate restrictions since relatively few farmers are violating this aspect of the Rule. However, since less than 70 percent of farmers knew that the maximum atrazine application rate is 2 lbs. per acre per year, yet rates of application were consistently below this ceiling, the high level of compliance may be a function of prevailing atrazine use patterns, and not a function of regulatory control.

The AMA/non-AMA comparisons indicate that while AMA farmers are more aware of their restriction status, they are violating atrazine rate restrictions at higher rates than are their non-AMA counterparts. This makes sense because the lower rate ceiling creates increased opportunities for violation.

Knowledge of specific issues related to atrazine management was found to be nearly identical for AMA and non-AMA respondents. The lack of a knowledge differential indicates that the stringency of AMA restrictions has not caused these producers to seek out information more aggressively than farmers subject to only statewide restrictions.

Regarding farm characteristics, farmers with larger farms, with higher gross incomes, and those who derive over sixty percent of their income from cash grains are more knowledgeable than their counterparts. These farm characteristics were also shown (**Focus Report 1**) to be correlated with likelihood of using atrazine on the sampled field. Because use of atrazine was found to be uncorrelated with level of knowledge, it would seem that larger, richer, more intense producers of cash grains are qualitatively different from their counterparts. This segment of the farm sector are observed to be better informed, and more likely to rely on atrazine. The connection between these features requires further investigation.

Table 34. Knowledge indices across farm types.

	Gross Income ($)		Farm Size (tillable acres)				Cash Crops (%)	
Measure of knowledge	**<40K**	**>40K**	**<150**	**151-250**	**251-500**	**>500**	**<60%**	**>60%**
Score 1 (range = 1 - 8)	5.2**	6.0**	5.4**	5.8**	6.2**	6.1**	5.8*	6.2*
Score 2 (range = -1 - +1)	0.5**	0.7**	0.6**	0.6**	0.7**	0.7**	0.6**	0.7**

* Indicates significance at the .05 level.
** Indicates significance at the .001 level.

Focus Report 4

Perception of Environmental Risk

Several groundwater studies have concluded that Wisconsin's groundwater is contaminated with atrazine. Results from the DATCP-sponsored Grade A Dairy Farm Well Water Quality Survey conducted between August 1988 and February 1989 suggest, with 95 percent confidence, that between 9 and 15 percent of Grade A wells in Wisconsin contain atrazine, and that those numbers increase to between 19 and 39 percent of wells when looking at only the South-central portion of the state. A follow-up study indicated that 17 percent of wells in this area had atrazine detects above the preventative action limit (PAL) of 0.35 ppb, and 2 percent were above the enforcement standard (ES) of 3.5 ppb. Similarly, the DATCP Groundwater Monitoring Project, which began in 1985, found that out of 35 test sites where atrazine was used, it has been detected in the groundwater at 25 of the sites, with 19 having detects above the PAL and 8 having detects above the ES. Additionally, the DNR/DATCP sampling of approximately 65 wells in the lower Wisconsin River Valley showed that 40 of those wells contained atrazine, with 30 having detects above the PAL and 7 having detects above the ES. In DATCP's Rural Well Sampling Program, results indicated that out of 2187 wells sampled, 215 had atrazine detects, with 127 above the PAL and 11 above the ES (Wisconsin Department of Agriculture, Trade and Consumer Protection, Final Environmental Impact Statement, November 1991).

The aim of this report is two-fold. First, in light of the above findings regarding groundwater contamination, this report will address farmers' perceptions of water quality and vulnerability. Second, since our results indicate that operators farming fields in AMAs are using lower rates of atrazine and are less likely to use atrazine than are operators farming fields not in AMAs (**Focus Report 1**), this report will investigate whether or not differences in atrazine use between these two groups of farmers are associated with differences in perceptions of environmental risk. Because of the intense media coverage and public debate surrounding the state's atrazine problem, it is reasonable to think that there may be differences between the perceptions of AMA and non-AMA farmers and between farmers who used atrazine and those who did not. It is possible that AMA status has heightened awareness of, and sensitivity to, groundwater pollution, and perhaps a portion of farmers who do not use atrazine are doing so out of environmental concern.

In addressing the above two issues, this report will answer the following questions: How do farmers rate the quality of drinking water -- past, present, and future? Are farmers who are using less atrazine doing so out of concerns about pollution? What and how many precautions are farmers taking to protect groundwater?

ASSESSMENTS OF WATER QUALITY

The assessments of past, present, and future water quality were nearly identical across the AMA and non-AMA areas, thus indicating that perception of risk is not a factor influencing AMA/non-AMA differences regarding atrazine use. Farmers in the AMAs averaged a water quality rating of 1.4*, and the non-AMA farmers' ratings also averaged 1.4. Similarly, AMA farmers rated the change in water quality over the past five years to be 0.0** while non-AMA farmers rated the change at a mere 0.1. Finally, AMA farmers predicted no change (0.0)** in water quality in the next five years, while non-AMA farmers' predictions averaged 0.1. In sum, both AMA and non-AMA farmers believed they had well-water quality that was close to excellent and that this had changed little over the last five years and would change little in the next five.

*Scale: -2 = very poor; +2 = excellent
**Scale: -2 = much worse; 0 = no change; +2 = much better

"Maybe by getting rid of chemicals everyone would be more healthy."

–Survey respondent comment

The results from a comparison of farmers who used atrazine on their weediest corn field with farmers who did not are almost identical to results from the AMA/non-AMA comparison. Once again this supports the claim that perception of environmental harm is not a causal factor in behavioral differences, specifically in terms of atrazine use. The average water quality ratings for the same questions as discussed above are as follows: both atrazine users and non- users rated water quality at 1.4; atrazine users rated water quality change over the last five years at 0.1, and non-users saw no change (0.0); atrazine users predicted a change in water quality over the next five years to be 0.1, while non-users predicted no change (0.0). None of these differences are statistically significant.

ATRAZINE USE AND POLLUTION CONCERNS

Farmers were asked to specify the reasons why they were using less atrazine if they were indeed using less. The choices were the following: using more crop rotations, problems with carry-over into alfalfa or other crops, on-farm ground water pollution concerns, increased mechanical cultivation, using more effective non-atrazine herbicides, atrazine restrictions, former corn ground into CRP or set aside, and community ground water pollution concerns. The choices most relevant to the question of differing perceptions of environmental harm are, obviously, "on-farm ground water pollution concerns" and "community ground water pollution concerns."

"I think that pesticides ... used in moderation and by their labels can be safe for our water and soil."

– Survey respondent comment

Almost identical percentages of AMA and non-AMA farmers indicated these pollution concerns as reasons for using less atrazine: 38.6 percent of AMA farmers and 36.7 percent of non-AMA farmers indicated on-farm ground water pollution concerns, and 30.0 percent of AMA farmers and 33.2 percent of non-AMA farmers indicated community ground water pollution concerns.

The same pattern holds for atrazine users and non-users: 35.6 percent of farmers who used atrazine on their weediest field and 33.2 percent of non-users indicated on-farm ground water pollution concerns. A third of users (33.3 %) and non-users (30.6%) cited community ground water pollution concerns as a reason for decreasing atrazine use.

To summarize, there are no significant differences between AMA and non-AMA farmers nor between atrazine users and non-users in terms of perception of environmental harm. One conclusion is that the Atrazine Rule is working (AMA farmers are using less atrazine) and that it is not differing perceptions of environmental risk that account for behavioral differences. Finally, the water quality ratings of those respondents who indicated on-farm or community ground water pollution concerns were not significantly different from the respondents as a whole.

PRECAUTIONS TO PROTECT DRINKING WATER

The performance of activities such as testing for nitrates, pesticides, and bacteria, drinking bottled water only, using a home water treatment system, or installing a back-siphon prevention device may indicate a concern for the quality of water. Overall, farmers used an average of 1.2 of the above six precautions (Table 35). This result implies that farmers are not particularly worried about the quality of their drinking water.

AMA and non-AMA farmers used 1.3 and 1.1 precautions, respectively, while atrazine users and non-users used 1.2 and 1.1 precautions, respectively. Again, there are no significant differences between groups here (Table 35).

CONCLUSION

Our respondents, in aggregate, do not appear to have significant environmental concern as indicated on several measures. Farmers rated water quality to be slightly below excellent, reported no significant change in water quality over the past five years, and expected no change in the next five years. While over 30 percent did explictly express groundwater pollution concerns, still over two-thirds did not. Approximately one-half of farmers test for nitrates yearly, less than half for bacteria, and approximately one-fifth test for pesticides. This low level of caution is observed in an era of growing public concern and media attention directed at pesticides in groundwater.

Although the data indicate no differences between AMA and non-AMA farmers, nor between atrazine users and non-users, on perceptions of past, present, and future water quality, on

Table 35. Percentages using various drinking water protection practices.

Precaution	Total % using	AMA farmers	Non-AMA farmers	Atrazine users	Non-users
Yearly nitrate testing	49.9%	53.0%	47.2%	56.3%	42.2%
Yearly pesticide testing	20.3	22.1	18.7	21.0	19.3
Yearly bacteria testing	44.1	45.3	43.0	45.1	42.8
Drink only bottled water	0.5	1.1	0.0	0.0	1.1
Using water treatment system	3.5	2.2	4.7	4.0	3.2
Install back-siphon system	30.9	30.9	30.8	29.0	31.0

pollution concerns, and on taking precautions to protect groundwater, there are still significant differences in use of atrazine. AMA farmers are using less atrazine than are non-AMA farmers, and, obviously, atrazine users are using more atrazine than are non-users. The above data indicate that it is not differing perceptions of environmental risk or harm that account for these behavioral differences.

To understand why some farmers are using less or no atrazine, we must look to the larger picture. This larger picture involves a range of influences and activities such as the emergence of increasingly viable alternatives (chemical and non-chemical), increasing dependence on professional "expertise", educational opportunities and, of course, tiered atrazine restrictions. There is undoubtedly a complex assortment of reasons why farmers, as a whole, have been using less atrazine in recent years. On the basis of this analysis, perception of risks posed by atrazine does not figure prominently in farmers' decision processes.

CONCLUSION

A major conclusion of this study is that the Atrazine Rule has achieved its objective, i.e., the Atrazine Rule has reduced extent and intensity of atrazine use. Relative to farmers in non-AMA areas, AMA farmers used atrazine on a lower percentage of corn acres, and applied atrazine at lower rates on atrazine-treated acres.

Atrazine use was most frequently observed on larger fields, larger farms, and in situations where corn was grown in multi-year sequences. The observed differences in rates across corn rotations represent persistent concerns regarding atrazine carry-over despite the low rate of application. The rates of atrazine application were not found to be correlated with either field size or farm size. Because field size was positively correlated with farm size, larger farms as a group may face a more pronounced adjustment to atrazine restrictions.

A high level of compliance with atrazine rate restrictions further testifies to the success of the Atrazine Rule. Wisconsin farmers have clearly demonstrated their willingness to meet restrictions even though they were able to identify significant additional costs to prevailing methods of corn production. Violation of rate restrictions for AMA and non-AMA farmers were 10.6 percent and 1.5 percent, respectively. Most of these violations were associated with the use of preblended tank mixes.

Clearly, relatively low rate atrazine application remains a popular component of weed management strategies. Sevety-two percent of those using atrazine on their weediest corn field applied one pound or less in 1992. Roughly 88 percent applied less than 1.5 pounds. Based on the documented popularity of low-rate atrazine applications, it is assumed that continued use will occur across a wide range of farming conditions during the 1993 growing season.

Relative to their counterparts in non-AMA areas, farmers operating within an AMA are not facing an agronomic disadvantage as represented by comparisons of yield loss predictions and assessments of weed intensity. As measured during this first growing season, the 1992 Atrazine Rule appears to have triggered no changes in corn production plans or future farm planning.

Product substitution appears to be the near-term response to the Atrazine Rule as supported by two findings: 1) farmers who did not use atrazine on the weediest corn field were significantly more likely to use non-atrazine herbicides than were atrazine users, and 2) AMA farmers were significantly more likely to use non-atrazine products than were non-AMA farmers. There are some indication that more sophisticated, multi-dimensional transition strategies are emerging. For a variety of non-atrazine alternatives (non-atrazine herbicides, reduced rate applications, banding, cultivation and rotary hoeing, and weed scouting), across a range of evaluation criteria (risk, profitability and labor requirements), farmers who did not use atrazine consistently reported more favorable assessments than did atrazine users.

Farmer's knowledge of the Atrazine Rule is uneven. Knowledge is weak in the areas of awareness of restriction status, what products do and do not contain atrazine, and when atrazine can be applied. Knowledge of rate restrictions appears to be strong since relatively few farmers violated this aspect of the Rule, though this high level of compliance may be a function of prevailing atrazine use patterns. AMA farmers violated rate restrictions to a greater extent than did non-AMA farmers, even though AMA farmers were, as a group, more aware of their restriction status. Farmers with larger farms, with higher gross incomes, and who derive over sixty percent of their income from cash grains are more know-

ledgeable of issues related to the Atrazine Rule than their counterparts.

Although this project represents an assessment of the 1992 restrictions, these results can be used to estimate probable impacts from the 1993 amendments to the Atrazine Rule. These data indicate that the Atrazine Rule will reduce atrazine loading to groundwater to the extent that these water resources were contaminated by past field surface application of atrazine. Yet in order to capture the full range of impacts associated with atrazine restrictions (notably, the pending 1993 amendments), measurement will be necessary across a greater time span. It will be important to understand the farmers' perceptions of incentives and obstacles in moving from short-term product substitution to more comprehensive changes in weed management strategies. Gaining an understanding of these obstacles and incentives early in the transition process offers the opportunity to manage for desireable outcomes. This study should be considered a baseline against which later analysis can be compared.

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APPENDIX A: Sampled Townships by County

DANE COUNTY

* Albion
Berry
Blooming Grove
* Blue Mounds
Bristol
Burke
* Christiana
Cottage Grove
Cross Plains
Dane
Deerfield
* Dunkirk
Dunn
Fitchburg
Madison
* Medina
Middleton
Montrose
Oregon
* Perry
** Pleasant Springs
** Primrose
** Rutland
Springdale
Springfield
** Sun Prairie
* Vermont
Verona
Vienna
Westport
Windsor
* York

GREEN COUNTY

** Albany
Brooklyn
* Decatur
Exeter
* Spring Grove
* Mt. Pleasant

COLUMBIA COUNTY

Arlington
* Columbus
Dekorra
* Fountain Prairie
* Hampden
Leeds
Lodi
Lowville
* Otsego

LAFAYETTE COUNTY

* Argyle
* Belmont
* Blanchard
Darlington
* Elk Grove
* Fayette
** Gratiot
** Kendall
* Lamont
Monticello
** Seymour
Shullsburg
* Wayne
** Willow Springs
* Wiota

ROCK COUNTY

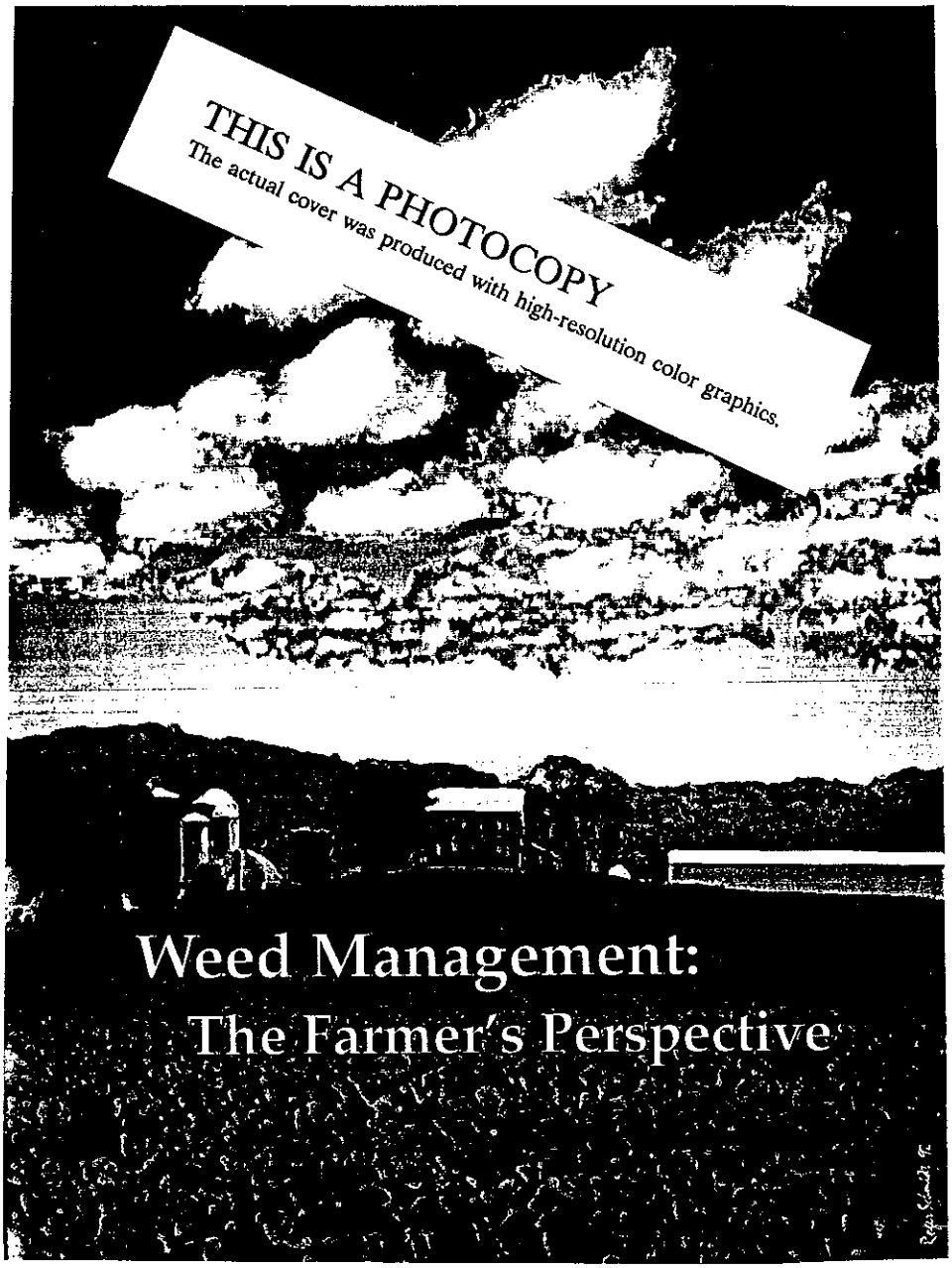
* Center
* Fulton
* Harmony
* Janesville
* Johnstown
* Lima
* Milton
* Porter
* Union

ST. CROIX COUNTY

* Baldwin
* Cady
* Cylon
* Eau Galle
* Emerald
Erin Prairie
* Forest
* Glenwood
Hammond
Kinnickinnic
Pleasant Valley
Richmond
Rush River
* Springfield
Warren

*** = Non-AMA**
**** = Portions of township in AMA and Non-AMA areas**
No symbol = AMA

APPENDIX B: Survey Instrument



August, 1992

I know you are busy. I also know you probably receive quite a few mail and telephone surveys. Yet your help is still needed.

A letter explaining the purpose of this survey and the importance of your participation should have reached you about a week or so ago. Let me briefly repeat the highlights of that letter.

- **The purpose of this survey is to listen to you.**
  Too often agricultural programs and policies are debated and decided without first listening to the views of the Wisconsin farmer.

- **Decisions are being made on the use of pesticides, atrazine in particular.**
  Regulations concerning the use of agricultural chemicals are currently being debated in Wisconsin. The full range of farmers' views on this complex issue need to be brought into the decision-making process.

- **Impacts of pesticide regulations on farmers must be understood.**
  Up to now, little attention has been paid to understanding weed management problems you and other farmers face. We need to understand how pesticide regulations may affect your ability to manage these problems.

Ideas based on your hands-on experience are needed to deal with these issues. That's why only you, along with other Wisconsin farmers, can provide this type of guidance.

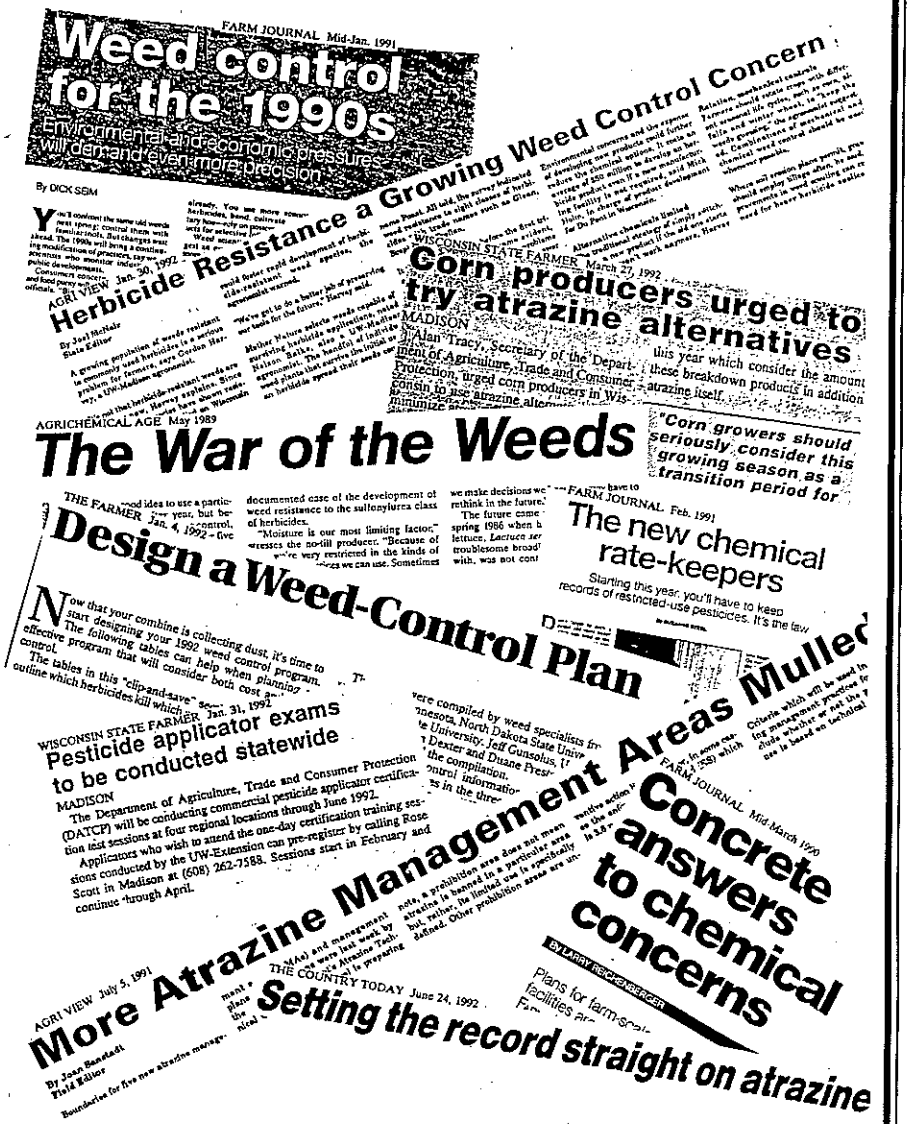
I guarantee your confidentiality. Information specific to your operation will not be included in any report. We will combine your answers into statistical reports to inform Wisconsin agricultural agencies, farm organizations and farm supply businesses. The last item in this survey offers you a copy of these same reports.

We have randomly selected only a limited number of farmers to receive this survey. So, you have the opportunity to speak for a number of other farmers by working with us.

Please take advantage of this opportunity to be part of the decision-making process by completing this survey as soon as possible. If you have any questions or concerns please call us at (608) 262-6049.

Sincerely,

Pete Nowak, Professor, UW-Madison
College of Agricultural and Life Sciences



Who should complete this questionnaire?

The questionnaire should be completed by the person most responsible for corn production decisions in 1992. Check the circle ⓥ that best applies.

- ○ I do not own, operate or manage a farm. → **Please stop here and return the survey in the enclosed envelope.**
- ○ No corn is being grown on any of the land that I own or operate in 1992. → **Please stop here and return the survey in the enclosed envelope.**
- ○ I own or rent all the land that I operate and I am growing corn in 1992. → **Please go to the next page!**
- ○ I am a hired manager, foreman or caretaker and I am growing corn in 1992. → **Please go to the next page!**
- ○ I lease out my corn land, employ someone to manage it for me, or have recently sold my farm.

Please fill in the name and address of the current operator below and return the survey in the enclosed envelope.

Operator's Name: _____

Operator's Address: _____

_____

_____

Operator's Phone #:( ) — _____

How to share your views

1. Make all responses dark and complete as shown in the examples below.
2. Feel free to write any comments or explanations on this survey.
3. Mail your completed form in the enclosed stamped, pre-addressed envelope.

Please answer all the questions to the best of your knowledge as your confidentiality is guaranteed.

Example Question 1

ow important are farmers' opinions?

First, we'd like you to tell us how much you agree or disagree with the following statements. Please check ⓥ the one that best applies.

	Strongly agree	Somewhat agree	Agree	Somewhat disagree	Strongly disagree
A. Farmers' views should be included in designing water quality programs.	○	○	○	○	○
B. Farmers can work out solutions to their own farm management problems.	○	○	○	○	○
C. The American public understands the concerns of the average farmer.	○	○	○	○	○

Example Question 2

To what extent does the weather influence your farm management decisions? **Check the circle ⓥ that best applies.**

None — A little — Some — A fair amount — A great deal

Field Description

All questions in this first section ask about your 1992 corn field with the most severe weed problem after ALL herbicide and cultivation treatments have been completed.

1. My 1992 corn field with the most severe weed problem after ALL of my herbicide and cultivation treatments have been completed is: (Check all that apply)

   ○ owned and managed by me
   ○ not owned but managed by me
   ○ operated under a cash rent agreement
   ○ operated under a crop share agreement

2. This field is _____ acres in size.

3. Which of the following soil texture groups are the first and second most common in this corn field?

	Most Common (check one)	2nd Most Common (check one)
A loam, silt loam, sandy clay loam or silt	○	○
A clay, sandy clay, silty clay, clay loam, or silty clay loam	○	○
A loamy fine/very fine sand, fine/very fine sandy loam	○	○
A sand, loamy sand, sandy loam, or sand with coarse fragments	○	○
Peat or muck	○	○
Don't know	○	○

4. Do you know the average organic matter content of the soil in this field?

   ○ No
   ○ Yes → What is the percentage of organic matter? _____ %

5. Please indicate the crops grown on this field in 1990, 1991 and 1992; and then the crops likely to be grown in 1993 and 1994. (Check all that apply)

1990	1991	1992	1993	1994
○ corn	○ corn	○ corn	○ corn	○ corn
○ sweet corn	○ sweet corn	○ sweet corn	○ sweet corn	○ sweet corn
○ alfalfa	○ alfalfa	○ seed corn	○ alfalfa	○ alfalfa
○ oats	○ oats		○ oats	○ oats
○ soybeans	○ soybeans		○ soybeans	○ soybeans
○ clover	○ clover		○ clover	○ clover
○ peas	○ peas		○ peas	○ peas
○ wheat	○ wheat		○ wheat	○ wheat
○ pasture	○ pasture		○ pasture	○ pasture
○ other	○ other		○ other	○ other

6. First, please check ✓ the weeds that were **in this same field** in 1991 and 1992. Then tell us the three weeds that gave you the most problems in 1992.

WEED NAME	1991 a. Check ✓ all weeds you were attempting to control last year.	1992 b. Check ✓ all weeds you were attempting to control this year.	Rank-1992 c. Which three weeds gave you the most problems this year? Put a 1 by the worst, a 2 by the second, and a 3 by the third.
Velvetleaf			
Pigweed			
Lambsquarters			
Mustard			
Foxtail			
Quackgrass			
Nutsedge			
Kochia			
Crabgrass			
Other -- Specify:			

7. Which of the following practices do you use to control weeds on this field? (Check all that apply)

   ○ Mechanical cultivation
   ○ Rotary hoeing
   ○ Crop rotation
   ○ Integrated Pest Management techniques as promoted by UW
   ○ Herbicides
   ○ Varietal seed selection with good weed resistance due to fast seedling development
   ○ Delay planting date
   ○ Other (Please describe: _____)

8. Which of the following practices do you use to estimate weed pressure in this field? (Check all that apply)

   ○ Custom applicator/crop consultant does this
   ○ Informal visual observations
   ○ Establish test (no treatment) plots and compare against treated portions of the field
   ○ Formal crop/weed scouting according to established procedures
   ○ I do not formally estimate weed intensity but regularly apply herbicides as part of growing corn
   ○ I use some other rule of thumb not listed above (Please describe: _____)

The next 4 questions ask about this same field with the most severe weed problem after all herbicide and cultivation treatments have been completed.

On the opposite page are five descriptions of **weed intensity** on a scale of 1 to 5.

For **Questions 9, 10, and 11**, select the number from the opposite page that best describes the intensity of your weed problem in this field after all herbicide and cultivation treatments have been completed.

9. The **average intensity** of weeds on the overall field this year is:

   (select a number from the opposite page) _____

10. The **highest intensity** on any one portion of the field this year is:

    (select a number from the opposite page) _____ ;

    and this highest intensity is present on _____ acres in this field in 1992.

11. If you grew corn on this field in 1991, what was the **average weed intensity** last year? If you did not grow corn on this field last year, go to Question 12.

    (select a number from the opposite page) _____

12. Please tell us about your yield goals and estimated yield losses in 1991 and 1992 due to weeds **on this field**. If you did not grow corn **on this field** in 1991, leave the column labeled 1991 blank.

	This year (1992)	Last year (1991)
Yield goals	_____ bushels/acre or _____ tons/acre	_____ bushels/acre or _____ tons/acre
Yield losses due to weeds (No loss = 0)	_____ bushels/acre or _____ tons/acre	_____ bushels/acre or _____ tons/acre

Weed Intensity Rating:

5
Have trouble finding the crop, field may be total loss.

4
Full weed ground cover.

3
Many weed seedlings and/or numerous large plants.

2
Occasional, scattered weed seedlings.

1
Weed-free; almost impossible to find a single weed.

Now we would like to ask about the possible use of atrazine in this same field with the most severe weed problem after all herbicide and cultivation treatments have been completed.

13. Is this field <u>currently</u> in an Atrazine Management Area or Atrazine Prohibition Area?

- ○ No, this field is currently not in an Atrazine Management Area or Atrazine Prohibition Area.
- ○ Yes, this field is currently in an Atrazine Management Area.
- ○ Yes, this field is currently in an Atrazine Prohibition Area.
- ○ I don't know.

14. Please indicate which products containing **atrazine** you used <u>**on this field in 1992**</u>. Please write in the name of **each compound and formulation** you used, even if it does not appear in the list printed below. Then provide **all** of the information for that application. Use a separate line for **each** application, even if you used the same compound more than once. If you did not use any atrazine in 1992, please go to Question 15.

Aatrex 4L	Aatrex Nine-O	Buctril + atrazine	Lariat
Atrazine 80W	Bicep	Extrazine II	Marksman
Aatrex 80W	Bullet	Laddok	Sutazine+

	1992 Application Time			*Rate*	*Area*	*Applicator*		*Use in 1991*	
Product and Formulation	**Post-emergent**	**Pre-emergent**	**Pre-plant**	**Rescue**	**Rate per acre on weediest field**	**Acres treated on weediest field**	**How was it applied?**		**Was this product used in an <u>identical</u> fashion in 1991?**	
							Self	**Custom**	**Yes**	**No**
Example: _____	○	○	○	○	_____ Lbs or _____ Qts		○	○	○	○
_____	○	○	○	○	_____ Lbs or _____ Qts		○	○	○	○
_____	○	○	○	○	_____ Lbs or _____ Qts		○	○	○	○
_____	○	○	○	○	_____ Lbs or _____ Qts		○	○	○	○
_____	○	○	○	○	_____ Lbs or _____ Qts		○	○	○	○

15. Has your use of atrazine **on this field** decreased from previous years?

- ○ No
- ○ Yes → Please list below the names of any **non-atrazine** herbicides you are using on this field **due to current atrazine restrictions.**

<u>Non-atrazine herbicides used as replacement for atrazine:</u>

1. _____
2. _____
3. _____
4. _____

16. Many farmers have reported using less atrazine in recent years. If you are using less atrazine, which of the following reasons explain why you made this decision? (Check all that apply)

- ○ using more crop rotations
- ○ on-farm ground water pollution concerns
- ○ using more effective non-atrazine herbicides
- ○ former corn ground into CRP or set aside
- ○ problems with carry over into alfalfa or other crops
- ○ increased mechanical cultivation
- ○ atrazine restrictions
- ○ community ground water pollution concerns
- ○ other (Specify: _____)

Now we would like to ask how this weediest corn field compares to your other corn fields.

17. In general, how do the following **application rates** on your weediest 1992 corn field compare to the rates on your other corn fields? Are they **higher**, the **same** or **lower**?

	<u>Higher</u>	<u>Same</u>	<u>Lower</u>	
My **nitrogen rates** are	○	○	○	on my weediest corn field than on my other corn fields.
My **manure rates** are	○	○	○	on my weediest corn field than on my other corn fields.
My **atrazine rates** are	○	○	○	on my weediest corn field than on my other corn fields.
My **non-atrazine herbicides rates** are	○	○	○	on my weediest corn field than on my other corn fields.

Weed Control Practices

Now, we are interested in your views and assessments of a number of weed control practices. Please evaluate each of the following practices even if you don't use them or know little about them.

18. How FAMILIAR are you with each of the following practices?

	Completely unfamiliar	*Only aware, but lack details*	*Know a little, but lack working knowledge*	*Fairly knowledgeable, have working knowledge*	*Fully understand as a local expert*
Non-atrazine herbicides — herbicides that do not contain atrazine such as Bladex, Accent and others	○	○	○	○	○
Reduced rate herbicide applications — weed control chemicals applied at rates below the label directions	○	○	○	○	○
Herbicide banding — the application of herbicide on planted rows only	○	○	○	○	○
Cultivation and rotary hoeing — mechanical control of weeds	○	○	○	○	○
Weed scouting — visual assessment of weed type and density before deciding on herbicide treatment	○	○	○	○	○

19. To what extent are you CURRENTLY USING each of the following practices in your farming operation?

	Nowhere on my farm	*Trying it on a small area on my farm*	*Over many, but not all areas on my farm*	*Everywhere possible on my farm*
Non-atrazine herbicides	○	○	○	○
Reduced rate herbicide applications	○	○	○	○
Herbicide banding	○	○	○	○
Cultivation and rotary hoeing	○	○	○	○
Weed scouting	○	○	○	○

20. How would each of these practices affect the PROFITS of your current farming operation?

	Large decrease in profits	*Small decrease in profits*	*No change in profits*	*Small increase in profits*	*Large increase in profits*
Non-atrazine herbicides	○	○	○	○	○
Reduced rate herbicide applications	○	○	○	○	○
Herbicide banding	○	○	○	○	○
Cultivation and rotary hoeing	○	○	○	○	○
Weed scouting	○	○	○	○	○

21. How would each of these practices affect the AMOUNT OF LABOR needed on your farm?

	Less labor needed	*No change in labor*	*Increased demand on current workers*	*Would require additional workers*
Non-atrazine herbicides	○	○	○	○
Reduced rate herbicide applications	○	○	○	○
Herbicide banding	○	○	○	○
Cultivation and rotary hoeing	○	○	○	○
Weed scouting	○	○	○	○

22. How RISKY would each of these practices be to use in your current farming operation?

	Large decrease in risk	*Small decrease in risk*	*No change in risk*	*Small increase in risk*	*Large increase in risk*
Non-atrazine herbicides	○	○	○	○	○
Reduced rate herbicide applications	○	○	○	○	○
Herbicide banding	○	○	○	○	○
Cultivation and rotary hoeing	○	○	○	○	○
Weed scouting	○	○	○	○	○

Herbicide Application

Go directly to Question 28 if ALL of your herbicides are custom applied.

23. What calibration method do you use to set your sprayer?

- ○ use last year's setting
- ○ spray test area and refill
- ○ use catch container for test run
- ○ use hand-held or in-line flow meter
- ○ readjust after spraying first tank
- ○ visually estimate and adjust ground speed accordingly
- ○ other (Specify: _____)

24. Please consider the set of sprayer nozzles you use most often for applying corn herbicides. Approximately how often do you replace this set of nozzles due to excessive wear? **Please check one of the following and fill in the blank.**

- ○ I replace my nozzles because of wear after spraying _____ acres.
- ○ I replace my nozzles because of wear after _____ hours of sprayer operation.
- ○ I don't calibrate my equipment but rely on experience for proper application.
- ○ I don't know.

25. How often do you calibrate your herbicide application equipment? **Please check one of the following and fill in the blank.**

- ○ I calibrate my equipment after spraying _____ acres.
- ○ I calibrate my equipment after _____ hours of sprayer operation.
- ○ I don't calibrate my equipment but rely on experience for proper application.
- ○ I don't know.

26. Are you a Wisconsin Department of Agriculture certified pesticide applicator?

- ○ Yes, I am a certified commercial applicator.
- ○ Yes, I am a certified private applicator.
- ○ No, I am not certified to apply restricted-use pesticides.

27. During the last two years, have you attended a workshop, field day, or education course on sprayer calibration or pesticide application (other than the applicator certification training)?

- ○ Yes
- ○ No

28. A number of other farmers, university personnel or agency staff have made the following statements. For each one, please indicate whether you think the statement is **Accurate**, **Not Accurate** or **Don't Know**.

	Accurate	Not Accurate	Don't Know
Only a certified applicator can legally apply atrazine.	○	○	○
Atrazine can be applied any time during the growing season.	○	○	○
Farmers inside Atrazine Management Areas (AMAs) are the only ones subject to atrazine use restrictions.	○	○	○
Any person who applies atrazine must keep written records for each application.	○	○	○
Soil texture is an important factor in determining the amount of atrazine that can be legally applied.	○	○	○
Pre-mixed herbicides such as Bicep, Bullet, and Lariat contain atrazine.	○	○	○
Routine calibration of sprayers is necessary to insure that herbicides are applied at the desired rate.	○	○	○
The maximum atrazine application rate of 2 lbs. per acre per year is only a suggestion and may be exceeded under certain conditions.	○	○	○

29. If atrazine use were banned in Wisconsin, how would each of the following factors be affected on your farm?

	Decreased	Unchanged	Increased	Don't know
My labor requirements would be	○	○	○	○
My management requirements would be	○	○	○	○
My use of crop rotations would be	○	○	○	○
My net farm income would be	○	○	○	○
My crop yields would be	○	○	○	○
My weed pressure would be	○	○	○	○
My cost of weed management would be	○	○	○	○

→ If the cost of weed management would change, how much? _____ $/acre

Agrichemical Supplier

Now we would like to ask several questions about the agrichemical supplier from whom you buy most of your agrichemicals. By agrichemicals we mean pesticides, fertilizer, and services related to the use of these products.

30. At which type of business do you spend the greatest amount of money on agrichemical products and agrichemical services each year? (Check one only)

- ○ Cooperative to which I belong
- ○ Cooperative to which I do not belong
- ○ An independent agrichemical dealer that is not part of a cooperative
- ○ Crop consultant/farm management service
- ○ Other (Please describe: _____)

31. What percentage of your **total** agrichemical products and services budget do you spend with the business checked above?

_____ %

32. How long has this business been the primary supplier of agrichemical products and services to your farm?

_____ years

33. Again, think of the business you checked above. Which of the following fertility management services does this business make available to you and which of their services are you currently using? (Check one circle for each service.)

	Not available	Available and I am using	Available and I am not using	Don't know if available
Fertilizer recommendations	○	○	○	○
Soil sampling	○	○	○	○
Soil testing (send samples to lab for analysis)	○	○	○	○
Soil test recommendations	○	○	○	○
Soil fertility mapping	○	○	○	○
Plant tissue testing	○	○	○	○
Manure analysis	○	○	○	○
Manure crediting	○	○	○	○
Calibration of manure spreaders	○	○	○	○
Sludge handling and/or application	○	○	○	○
Custom application of fertilizers	○	○	○	○
Record keeping	○	○	○	○
Other (Specify: _____)	○	○	○	○

34. Which of the following insect and/or weed management services does this business make available to you and which of their services are you currently using? (Check one circle for each service.)

	Not available	Available and I am using	Available and I am not using	Don't know if available
Sells pesticides to me	○	○	○	○
Rents pesticide application equipment to me	○	○	○	○
Rents mechanical weeding equipment to me	○	○	○	○
Recommends pesticide products	○	○	○	○
Recommends pesticide rates	○	○	○	○
Scouting (routine schedule)	○	○	○	○
Scouting (occasional visits or upon request)	○	○	○	○
Weed mapping	○	○	○	○
Crop rotation advice	○	○	○	○
Field sprayer calibration	○	○	○	○
Planter calibration for insecticides	○	○	○	○
Custom application of pesticides	○	○	○	○
Computer programs to assist in pest management	○	○	○	○
Record keeping as required by the atrazine rule	○	○	○	○
Other (Please describe: _____)	○	○	○	○

35. Has this primary supplier of agrichemical products and services ever encouraged you to apply herbicides at rates below label recommendations?

- ○ Yes
- ○ No

36. How does your primary supplier of agrichemicals learn about the needs and requirements of your farming operation? (Check all that apply)

- ○ through mail surveys
- ○ through farm visits
- ○ through casual, social contact
- ○ through over-the-counter discussions
- ○ through telephone conversations
- ○ through county agricultural offices
- ○ my supplier generally doesn't know much about my farming operation
- ○ I don't know
- ○ other (Please describe: _____)

37. The following are a series of statements that other farmers have used to describe their relations with their agrichemical dealers. Please check ✓ the three reasons that best describe why you work with your primary supplier of agrichemicals and commercial fertilizer.

Reasons Why This is My Primary Agrichemical Dealer:	Check Only Three
Assists in the identification of weeds and other pests	○
Offers new products and services to be tried on my farm	○
Offers quality products that have worked in the past	○
Provides just what I ask for and does not try to push unwanted products and services	○
Provides information that can be trusted	○
Helps me understand and meet the requirements of various pesticide laws and restrictions	○
Offers products and services at a competitive price	○
Willingness to come to my farm to get detailed information on a pest or nutrient problem	○
Provides a reliable source of information on crop production	○
Helps me credit on-farm nutrients (legumes and manures) so that I don't have to buy more fertilizer than needed	○
They are the closest agrichemical dealer to my farm	○
They provide an annual rebate check based on the amount I have spent	○
I have known the people who work at the dealership most of my life	○

38. **How much information** on each of the following topics has this primary supplier of agrichemicals provided to you?

Topics:	Amount of Information Provided: None	A little	A fair amount	A great deal
Responsibilities under the atrazine rule	○	○	○	○
Pesticide handling, loading, storage and disposal practices	○	○	○	○
Non-atrazine herbicides	○	○	○	○
Mechanical weed control	○	○	○	○
Record keeping requirements under the atrazine rule	○	○	○	○
Maximum allowable atrazine application rates	○	○	○	○

On-Farm Drinking Water

39. What is the primary source of your household water?

○ private well ○ municipal/public supply

40. Which of the following precautions have you taken to protect your **drinking water**? (Check any that apply)

○ test for nitrates at least once a year ○ drink bottled water only
○ test for pesticides at least once a year ○ use a home water treatment system
○ test for bacteria at least once a year ○ installed back-siphon prevention devices
○ other (Specify: _____)

41. How would you rate the quality of your drinking water? (Check the appropriate circle below)

-2 -1 0 +1 +2
Very Poor **Excellent**

42. How has the quality of your drinking water changed in the last five years?

-2 -1 0 +1 +2
Much Worse **No Change** **Much Better**

43. Relative to today, what do you think the quality of your drinking water will be in five years?

-2 -1 0 +1 +2
Much Worse **No Change** **Much Better**

44. Where is atrazine <u>usually</u> loaded into your field sprayer for application on your farm? (Check only one)

○ at an off-farm facility (dealer's yard, custom applicator's yard)
○ in the field
○ at the farmstead
→ Is this loading area within 50 feet of the well that serves as your primary source of drinking water?
○ No
○ Yes

45. Which of the following categories describes the surface of the atrazine loading site checked in Question 44? If there are no loading sites on your farm, please go to Question 46.

○ dirt/grass ○ gravel/crushed rock
○ blacktop/asphalt ○ concrete

Farm Planning

In this section, please consider the following questions about your farming operation for the year 1992.

46. Is any part of the land you operate or own currently in an Atrazine Management Area or Atrazine Prohibition Area?

- ○ None of the land I operate or own is currently in an Atrazine Management Area or Atrazine Prohibition Area.
- ○ I don't know.
- ○ Yes, part or all of the land I operate or own is currently in an Atrazine Management Area.
- ○ Yes, part or all of the land I operate or own is currently in an Atrazine Prohibition Area.

→ **If yes:**

Was any of this land planted to corn in 1992? ○ No ○ Yes

Will any of this land be planted to corn in 1993 or 1994? ○ No ○ Yes

47. Please estimate the tillable acreage (owned or rented) of your farming operation in 1992:

_____ tillable acres

48. In 1992, how many acres of the following did you operate:

field corn _____ Acres
soybeans _____ Acres
small grains _____ Acres
canning crops _____ Acres
alfalfa/hay _____ Acres
pasture _____ Acres
set aside or CRP _____ Acres

49. What is the average corn yield of your farm operation?

_____ bushels/acre

or _____ tons/acre

50. From the following general categories below, please select the range which best describes your total **gross farm income** in 1992. (Total gross farm income includes the value of products sold, farm land rental income, custom work, government programs, etc.)

- ○ $1--$4,999
- ○ $5,000--$9,999
- ○ $10,000--$14,999
- ○ $15,000--$19,999
- ○ $20,000--$39,999
- ○ $40,000--$59,999
- ○ $60,000--$79,999
- ○ $80,000--$99,999
- ○ $100,000--$199,999
- ○ $200,000--$299,999
- ○ $300,000 or more

51. What percentage of your 1992 **gross farm income** came from each of the following sources? (Check one circle in each box)

The categories should add up to roughly 100 percent:

Dairy (milk production only)		Livestock (animals sold)		Cash Crops		Government Programs		Other		
○ none	+	○ none	+	○ none	+	○ none	+	○ none	=	Total
○ 1-19%		○ 1-19%		○ 1-19%		○ 1-19%		○ 1-19%		100%
○ 20-39%		○ 20-39%		○ 20-39%		○ 20-39%		○ 20-39%		
○ 40-59%		○ 40-59%		○ 40-59%		○ 40-59%		○ 40-59%		
○ 60-79%		○ 60-79%		○ 60-79%		○ 60-79%		○ 60-79%		
○ 80-100%		○ 80-100%		○ 80-100%		○ 80-100%		○ 80-100%		

52. How long have you managed your current farming operation?

_____ years

53. What changes in your farming operation are you planning over the next 5 years? (Check all that apply)

I plan to >>>>	stop	decrease	stay the same	start or increase
dairy				
livestock				
corn				
soybeans				
forage				

Please turn the page and open the fold-out map.
Directions for completing the map are printed on the next page.

Geographic Information

Please refer to the county area map to the right. Using the red pen enclosed with this survey, label the map as indicated below.

p.s. Please feel free to keep the pen.

1. Put a small red "X" on the approximate location of the **corn field with the most severe weed problem** you identified earlier.

Weediest corn field X

2. Now put a small red "D" on the approximate location of the **agrichemical dealer** you identified earlier.

Your agrichemical dealer ..... D

3. Finally, put a small red "H" on the approximate location of your **home**.

Your home ..... H

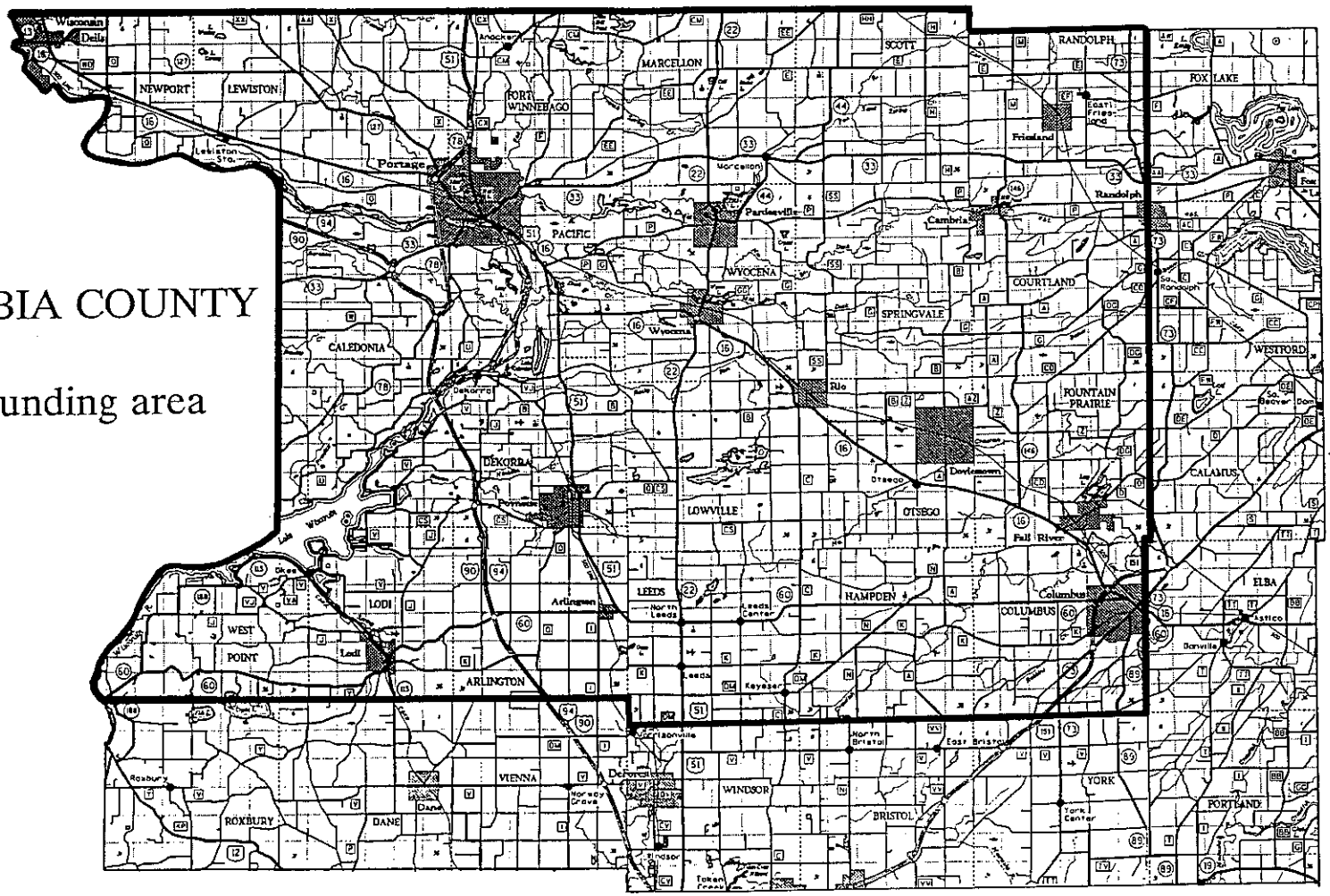
If the location of your field or home is not on the mapped area to the right, please write in the civil town name and section number below.

	Civil Town	Section Number
Field		
Home		

After labeling the map as requested, please make any comments you have in the space below. Feel free to use the back cover as well. Thank you for sharing your time and your perspective.

Comments:

If you would like to receive a copy of the results of this survey in approximately four months, please check this box. ➡ ☐



Sample county map

APPENDIX C: Response Frequency Charts

FIELD DESCRIPTION

Q1	My 1992 corn field with the most severe problem after herbicide and cultivation treatment:	AMA n=221	CON n=261	TOT n=502
	Owned and managed by me	71.9	77.4	74.7
	Not owned but managed by me	8.1	5.7	6.8
	Operated under a cash rent agreement	21.3	18.4	19.7
	Operated under a crop share agreement	3.6	3.8	4.1

Q2	This field is ____(acres) in size:	AMA n=216	CON n=258	TOT n=488
	Field Size (acres) Mean (std. dev.)	33.0 (47.1)	30.5 (53.0)	31.9 (50.3)

Q3	Which of the following soil texture groups is the most common in this field:	AMA 48.1	CON 47.5	TOT 47.6
	A loam, silt loam, sandy clay loam or silt	39.7	41.7	40.9
	A clay, sandy clay, silty clay, clay loam or silty clay loam	1.9	2.3	2.1
	A loamy fine / very fine sand, fine / very fine sandy loam	4.7	2.7	3.7
	A sand, loamy sand, sandy loam, or sand with coarse fragments	4.7	3.9	4.3
	Peat and muck	0.9	1.9	1.6

Q4	Do you know the average organic matter content of the soil in this field:	AMA n=214	CON n=253	TOT n=485
	% of yes responses	27.1	32.8	29.9

Q5	Indicate crops grown on this field in 1990, 1991, and 1992 and then the crops likely to be grown in 1993 and 1994:	AMA n=217	CON n=262	TOT n=495
	Continuous corn- corn in at least 1991, 1992, and 1993	41.7	29.4	34.7
	1st year corn- non-corn crop in 1991, followed by corn in 1992 and 1993	17.2	17.9	17.4
	Last year corn- corn in at least 1991 and 1992 but not 1993	25	34.1	30.6
	Other- corn in 1992, but no corn in 1991 or 1993	16.2	18.7	17.4

Q6	Identify the weed species that were in this same field in 1991 and 1992. Then tell us the three weeds that gave you the most problems in 1992.

Q6 a

Weeds present on this field: AMA only

Weed Name	Weeds for 91	Weeds for 92	#1 weed prob. for 92
Velvetleaf	71.6	80.3	21.7
Pigweed	29.2	38.2	2.4
Lambs 1/4,s	37.9	48.6	8.9
Mustard	5.8	9.2	0.5
Foxtail	71.4	82.3	36.1
Quackgrass	41.4	43.5	7.9
Nutsedge	27.5	32.2	5.2
Kochia	2.5	3.1	0.5
Crabgrass	9.9	9.9	1.1

Q6 b

Weeds present on this field: CON only

Weed Name	Weeds for 91	Weeds for 92	#1 weed prob for 92
Velvetleaf	73.2	83.2	18.7
Pigweed	34.2	40.3	1.6
Lambs 1/4,s	39.1	48.6	9.3
Mustard	5.6	6.8	0.8
Foxtail	72.8	85.3	37.7
Quackgrass	45.9	46.5	10.5
Nutsedge	21.3	24.9	3.2
Kochia	0.8	1.2	0.4
Crabgrass	9	10.6	0.4

Q6 c

Weeds present on this field: TOTAL

Weed Name	Weeds for 91	Weeds for 92	#1 weed prob for 92
Velvetleaf	72.1	81	19.8
Pigweed	31.1	38	1.8
Lambs 1/4,s	37.7	47.6	9.4
Mustard	5.5	7.6	0.6
Foxtail	71.9	83.4	36.7
Quackgrass	43.4	45	9.2
Nutsedge	23.8	27.8	4.2
Kochia	1.5	2.1	0.4
Crabgrass	9.2	10.1	0.6

Q7	Which of the following practices do you use to control weeds on this field:	AMA n=221	CON n=267	TOT n=507
	Mechanical cultivation	90.5	90.6	90.3
	Rotary hoeing	35.3	39.3	37.3
	IPM techniques as promoted by the UW	6.3	3.4	4.5
	Herbicides	91.4	94.8	92.9
	Varietal seed seed selection with good weed resistance	3.6	3.4	3.4
	Delay planting date	5.9	4.9	5.1
	Crop Rotation	48.1	56.6	52.3

Q8	Which of the following practices do you use to estimate weed presure in this field:	AMA n=220	CON n=266	TOT n=504
	Custom applicator/crop consultant does this	28.2	27.8	27.8
	Informal visual observations	69.5	62.1	64.5
	Establish test (no treat.) plots and compare against treated portions of field	2.7	1.5	2.1
	Formal crop/weed scouting according to established procedures	15.5	15.1	15.3
	I do not formally estimate weed intensity but reg. apply herbicides	35.9	42.5	39.7
	I use some other rule of thumb not listed above	5.1	8.6	7.1

Q9	Average intensity of weeds on the over all field this year:	AMA n=219	CON n=268	TOT n=504
	Weed Free / Almost impossible to find a weed	0.9	1.1	1.2
	Occasional, scattered weed seedlings	32.1	32.8	32.9
	Many weed seedlings and/or numerous large plants	47.5	45.9	46.2
	Full weed ground cover	16.9	14.9	15.5
	Have trouble finding crop / field may be total loss	2.7	5.2	4.2

Q10		AMA	CON	TOT
	Highest intensity on any one portion of the field this year:	n=219	n=267	n=499
	Weed Free / Almost impossible to find a weed	1.4	1.5	1.6
	Occasional, scattered weed seedlings	8.7	5.2	7
	Many weed seedlings and/or numerous large plants	27.4	33	30.7
	Full weed ground cover	38.4	36.7	37.3
	Have trouble finding crop / field may be total loss	24.2	23.6	23.4

Q11		AMA	CON	TOT
	Average weed intensity last year:	n=157	n=180	n=350
	Weed free / Almost impossible to find a weed	12.7	13.3	13.7
	Occasional, scattered weed seedlings	56.1	56.7	56.1
	Many weed seedlings and / or numerous large plants	21.2	18.3	19.4
	Full weed ground cover	7.1	8.9	7.7
	Have trouble finding crop / firld may be total loss	2.5	2.8	2.6

Q12			1991	1992
	Yield goals and yield losses due to weeds (Bushels / Acre)			
	Yield Goals (Bushels / Acre)	AMA	132.5 (28.3)	129.2 (27.6)
		CON	128.5 (27.8)	125.8 (30.8)
		TOT	129.9 (28.7)	127.3 (29.4)
	Yield Losses due to weeds (Bushels / Acre)	AMA	17.1 (26.6)	29.6 (29.8)
		CON	19.1 (31.8)	27.8 (27.4)
		TOT	18.0 (29.3)	28.3 (28.3)
	mean (std. dev.)			

Q13		AMA	CON	TOT
	Is this field currently a AMA or an APA:	n=211	n=257	n=485
	No, this field is currently not in a AMA or APA	14.7	34.6	25.8
	Yes, this field is currently in a AMA	68.7	48.6	56.1
	Yes, this field is currently in a APA	6.6	3.5	5.8
	I don't know	10.0	13.2	12.4

Q14	Indicate which products containing atrazine you used on this field in 1992 ?	AMA	CON	TOT
	Rescue	5.0	2.0	3.2
	Post-em	40.0	46.9	44.1
	Pre-em	47.0	42.2	44.1
	Pre-plant	8.0	8.8	8.5
	% custom applied	0.59	0.58	0.58
	Average rate active ingredient atrazine applied mean (	.74 (.036)	.975 (.042)	.88 (.030)

(% of atrazine users using products)	TOT
Marksman	29.8
Aatrex 4l	22.7
Aatrex 9-0	12.1
Bicep	8.2
Bullet	7.8
Atrazine 80W	7.4
Extrazine 2	4.6
Lariat	2.8
Aatrex 80W	1.8
Buctril+Atrazine	1.1
Laddok	1.1

Q15		AMA	CON	TOT
	Has the use of atrazine on this field decresed in previous y	n=194	n=235	n=445
	Yes	85.6	74.5	80
	No	14.4	25.5	20

Non-atrazine herbicides used as replacement for atrazine:

% of users of these products using each product:	TOT
Bladex	27.4
Lasso	16.8
Banuel	11.9
Prowl	9.6
Accent	6.2
Dual	6.0
2-4-D	5.7
Roundup	4.1
Buctril	3.8
Partner	1.9
Basagran	1.9
Eradicane	1.6
Ranger	1.2
Beacon	1.0
Cycle	0.1

Q16	Many farmers have reported using less atrazine in recent years. If you are using less, which of the following explains why:	AMA n=209	CON n=256	TOT n=483
	Using more crop rotations	34.9	43.8	39.2
	Problems with carry over into alfalfa or other crops	49	52	50.1
	On-farm ground water pollution concerns	38.6	36.7	37.3
	Increased mechanical cultivaton	30.5	25.4	27.7
	Using more effective non-atrazine herbicides	32.9	43.8	38.7
	Atrazine restictions	61.4	43.4	51.6
	Former corn ground into CRP or set aside	0.5	2.3	1.4
	Community ground water pollution concerns	30	33.2	32.1

Q17	How do the following application rates on your weediest 1992 corn field compare to the rates on your other corn fields:		Higher	Same	Lower
	NITROGEN rates are:	AMA	3.4	90.1	6.4
		CON	3.1	90.6	6.3
		TOT	3.4	90.5	6.1
	MANURE rates are:	AMA	17.7	64.1	18.2
		CON	17.5	68.2	14.3
		TOT	17.5	66.6	15.9
	ATRAZINE rates are:	AMA	7.2	69.7	23.1
		CON	6.3	70.2	23.2
		TOT	6.5	70.1	23.2
	NON-ATRAZINE HERBICIDE rates are:	AMA	21.5	69.1	8.9
		CON	20.1	75.2	4.7
		TOT	20.6	72.7	6.4

WEED CONTROL PRACTICES

Q18	How familiar are you with each of the following practices:	AMA n=220	CON n=264	TOT n=504
	Non-atrazine herbicides	3.7 (.85)	3.7 (.80)	3.7 (.82)
	Reduce rate herbicide applications	3.3 (1.0)	3.2 (.95)	3.2 (.98)
	Herbicide banding	2.8 (1.0)	2.8 (1.0)	2.8 (1.0)
	Cultivation and rotary hoeing	4.2 (.81)	4.2 (.59)	4.2 (.72)
	Weed scouting	3.6 (.94)	3.7 (.77)	3.6 (.86)
	Reported value represents score on a five point scale (1-5) [mean (std. dev.)]			

Q19	To what extent are you currently using each of the following practices in your farming operation:	AMA	CON	TOT
		n=216	n=259	n=493
	Non-atrazine herbicides	3.2 (.98)	3.1 (1.2)	3.1 (1.1)
	Reduce rate herbicide applications	2.5 (1.1)	2.5 (1.1)	2.5 (1.1)
	Herbicide banding	1.2 (.77)	1.2 (.75)	1.2 (.76)
	Cultivation and rotary hoeing	3.6 (.70)	3.6 (.69)	3.6 (.68)
	Weed scouting	3.3 (.97)	3.3 (.95)	3.3 (.96)
	Reported value represents score on a four point scale (1-4) [mean (std. dev.)]			

Q20	How would each of these practices affect the profits of your current farming operation:	AMA	CON	TOT
		n=214	n=256	n=489
	Non-atrazine herbicides	2.4 (.98)	2.4 (.98)	2.4 (.98)
	Reduce rate herbicide applications	2.6 (1.1)	2.7 (1.1)	2.6 (1.1)
	Herbicide banding	2.8 (1.1)	2.8 (1.1)	2.8 (1.1)
	Cultivation and rotary hoeing	3.5 (1.1)	3.7 (.99)	3.6 (1.1)
	Weed scouting	3.7 (.93)	3.7 (.95)	3.7 (.942)
	Reported value represents score on a five point scale (1-5) [mean (std. dev.)]			

Q21	How would each of these practices affect the amount of labor needed on your farm:	AMA	CON	TOT
		n=213	n=261	n=493
	Non-atrazine herbicides	2.3 (.73)	2.2 (.66)	2.2 (.69)
	Reduce rate herbicide applications	2.4 (.63)	2.3 (.61)	2.4 (.62)
	Herbicide banding	2.5 (.71)	2.4 (.68)	2.4 (.70)
	Cultivation and rotary hoeing	2.7 (.70)	2.7 (.67)	2.7 (.69)
	Weed scouting	2.5 (.72)	2.4 (.65)	2.5 (.68)
	Reported value represents score on a four point scale (1-4) [mean(std. dev.)]			

Q22	How risky would each of these practices be to use in your current farming operation:	AMA	CON	TOT
		n=217	n=258	n=493
	Non-atrazine herbicides	3.3 (1.0)	3.4 (.93)	3.3 (.96)
	Reduce rate herbicide applications	3.7 (.98)	3.6 (.90)	3.6 (.94
	Herbicide banding	3.6 (.97)	3.6 (.87)	3.6 (.91)
	Cultivation and rotary hoeing	2.9 (.95)	2.9 (.91)	2.9 (.94)
	Weed scouting	2.5 (.92)	2.6 (.95)	2.5 (.95)
	Reported value represents score on a five point scale (1-5) [mean (std. dev.)]			

HERBICIDE APPLICATION

Q23	What calibration method do you use to set your sprayer for applying corn herbicides:	AMA n=141	CON n=146	TOT n=299
	Use last years setting	26.2	31.5	28.8
	Spray test area and refill	19.9	23.3	21.4
	Use catch container for test run	39.7	32.2	35.8
	Use hand-held or in-line flow meter	7.8	7.5	7.4
	Readjust after spraying first tank	23.1	23.3	22.1
	Visually estimate and adjust ground speed accordingly	12.8	11.6	12.7

Q24	How often do you replace your corn herbicide sprayer nozzles:	AMA n=129	CON n=133	TOT n=274
	Nozzle replacement due to wear (Acres)	53.5	49.6	51.1
	Nozzle replacement due to wear (Hours)	3.9	8.5	5.9
	Nozzle replacement (Based on experience)	21.6	29.7	26
	Don't know	23.2	14	18.4

Q25	How often do you calibrate your herbicide equipment:	AMA n=131	CON n=126	TOT n=269
	Nozzle calibration due to wear (Acres)	56.5	51.6	53.2
	Nozzle calibration due to wear (Hours)	4.6	4.1	4.1
	Nozzle calibration (Based on experience)	31.5	39.7	35.8
	Don't know	7.1	4.8	6.1

Q26	Are you a Wisconsin Department of Agriculture certified pesticide applicator:	AMA n=140	CON n=145	TOT n=297
	Yes, I am a certified commercial applicator	7.1	3.4	5.7
	Yes, I am a certified private applicator	87.1	93.1	88.6
	No, I am not certified to apply restricted-use pesticides	5.7	3.4	5.4

Q27	During the last two years, have you attended a workshop, field day or education course on sprayer calibration or pesticide application:	AMA n=140	CON n=143	TOT n=296
	Yes	43.6	49.7	47.1
	No	56.4	50.3	52.7

Q28	For each statement indicate whether you think the statement is accurate, not accurate, or don't know:		Accurate	Not Accurate	Don't Know
	Only a certified applicator can legally apply atrazine.	AMA	73.2	24.5	2.3
		CON	70.8	23.7	5.4
		TOT	72.1	23.9	4.1
	Atrazine can be applied any time during the growing season.	AMA	20.5	64.7	13.4
		CON	23.1	61.9	9.7
		TOT	22.4	62.1	11.5
	Farmers inside Atrazine Management Areas (AMAs) are the only ones subject to atrazine use restictions	AMA	17.7	65.9	16.4
		CON	15.2	69.5	15.2
		TOT	16.1	68.3	15.8
	Any person who applies atrazine must keep written records for each application.	AMA	84.6	6.3	9.1
		CON	89.1	4.3	6.6
		TOT	86.5	5.4	8.1
	Soil texture is an important factor in determining the amount of atrazine that can be legally applied.	AMA	87.3	8.6	4.1
		CON	91.1	4.3	4.7
		TOT	88.8	6.6	4.6
	Pre-mixed herbicides such as Bicep, Bullet, and Lariat contain atrazine.	AMA	65.8	4.1	30.1
		CON	66.5	3.6	29.9
		TOT	65.6	4.3	30.1
	Routine calibration of sprayers is necessary to insure that herbicides are applied at the desired rate.	AMA	94.1	3.2	2.7
		CON	97.3	0.8	1.9
		TOT	95.4	2.1	2.6
	The maximum atrazine application rate of 2 lbs. per acre per year is only a suggestion and may be exceeded under certain conditions.	AMA	15.9	71.4	12.7
		CON	18.5	63.8	17.7
		TOT	16.6	67.5	15.8

Q29 a	If atrazine use were banned in Wisconsin, how would each of the following factors be affected on your farm:		D*	UC*	I*	DK*
	My labor requirements would be:	AMA	n/a	51.4	44.5	4.1
		CON	0.8	50.8	45.3	3.1
		TOT	0.4	50.3	45.7	3.6
	My management requirements would be:	AMA	n/a	37.6	60.2	2.3
		CON	0.4	38.1	58.4	3.1
		TOT	0.2	38.2	58.8	2.8
	My use of crop rotations would be:	AMA	0.9	67.7	28.6	2.7
		CON	2.8	68.5	27.6	1.2
		TOT	1.8	67.7	28.4	2.1
	My net farm income would be:	AMA	50.7	33.5	4.2	11.6
		CON	52.6	32.8	4.1	10.7
		TOT	51.5	33.1	3.9	11.5
	My crop yields would be:	AMA	37.1	49.8	1.4	11.8
		CON	33.5	53.1	2.1	11.4
		TOT	35.4	51.1	1.6	11.9
	My weed pressure would be:	AMA	1.4	33.9	56.6	8.1
		CON	1.6	37.9	57.8	8.7
		TOT	1.6	36.2	53.6	8.5
	My cost of weed management would be:	AMA	1.8	22.9	67.9	7.3
		CON	3.6	23.7	62.2	10.4
		TOT	2.7	23.5	64.6	9.3

(*) D = Decreased U=Unchanged I=Increased DK=Don't know

Q29 b	If the cost of weed mgmt. would change, how much____$ / Acre	AMA n=113	CON n=113	TOT n=232
	Affect on weed management ($ / acre) mean (std dev)	11.8 (10.7)	10.9 (7.8)	11.4 (9.6)

AGRICHEMICAL SUPPLIER

Q30	At which type of business do you spend the greatest amount of money on agrichemical products and services each year:	AMA n=222	CON n=265	TOT n=507
	Cooperative to which I belong	60.4	51.7	55.4
	Cooperative to which I do not belong	5.0	7.2	6.3
	Independent agrichemical dealer that is not part of a Co-op	32.9	38.9	36.3

Q31	What percentage of you total agrichemical products and services budget do you spend with the business checked above	AMA n=217	CON n=257	TOT n=490
	Percentage of purchases with #1 dealer (%)	88.2 (19.9)	94.0 (53.1)	91.1(40.9)

Q32	How long has this business been the primary supplier of agrichemical products and services to your farm:	AMA n=213	CON n=258	TOT n=489
	Number of years mean [std. dev.]	14.7 (12.1)	14.4 (11.8)	14.5 (11.8)

Q33	Which of the following fertility management services does this business make available to you and which of their services are you currently using:

AMA n=222	NA*	AU*	ANU*
Fertilizer Recommendations	1.8	68.9	27.5
Soil Sampling	2.7	64.1	28.4
Soil Testing (send samples to lab)	1.4	67.1	26.7
Soil Test recommendations	1.8	64.3	29.4
Soil Fertility Mapping	6.4	33.1	26.1
Plant Tissue Testing	8.3	8.3	38.4
Manure Analysis	11.1	5.2	30.5
Manure Crediting	7.1	29.4	28.1
Calibration of Manure Spreaders	18.6	4.3	13.8
Sludge Handling and/or Application	31.6	1.4	11.5
Custom Application of Fertilizers	2.7	56.8	37.7
Record Keeping	8.2	40.3	20.9
Other	0.7	3.7	0.7

CON n=265	NA*	AU*	ANU*
Fertilizer Recommendations	1.1	77.7	21.1
Soil Sampling	2.7	73.1	22.3
Soil Testing (send samples to lab)	1.5	75.6	20.6
Soil Test Recommendations	1.1	74.4	21.8
Soil Fertility Mapping	8.6	42.2	21.6
Plant Tissue Testing	8.6	11.7	32.4
Manure Analysis	10.2	11.4	21.7
Manure Crediting	6.3	32.8	22.7
Calibration of Manure Spreaders	24.1	2.8	14.2
Sludge Handling and/or Application	37.8	1.6	6.1
Custom Application of Fertilizers	2.7	66.1	28.6
Record Keeping	7	43.8	18.2
Other	0	4.7	0

TOT n=505	NA*	AU*	ANU*
Fertilizer Recommendations	1.4	74.1	23.8
Soil Sampling	2.6	69.1	25.2
Soil Testing (send samples to lab)	1.4	71.7	23.6
Soil Test Recommendations	1.4	69.8	25.4
Soil Fertility Mapping	7.8	37.8	24.1
Plant Tissue Testing	9.4	10.1	34.7
Manure Analysis	10.9	9.4	25.5
Manure Crediting	6.6	31.5	25.3
Calibration of Manure Spreaders	22.2	3.8	13.8
Sludge Handling and/or Application	35.6	1.5	8.5
Custom Application of Fertilizers	2.6	62.2	32.6
Record Keeping	7.5	42.3	19.9
Other	0.3	4.1	0.3

(*) NA = not availible AU=available and using ANU=available and not using DK=don't know

Q34 **Which of the following insect and/or weed management services does this business make availible to you and which of their services are you using:**

AMA n=219	NA*	AU*	ANU*	DK*
Sells pesticides to me	0.5	88.6	2.3	2.3
Rents pesticide application equipment to me	27.1	5.6	30.2	37.2
Rents mechanicle weeding equipment to me	51.2	3.7	12.6	32.6
Recommends pesticide products	0.0	80.1	15.9	3.6
Recommends pesticide rates	0.9	80.3	14.7	3.7
Scouting (routine schedual)	11.1	22.7	41.7	24.5
Scouting (occasional visits or upon requests)	4.1	57.6	22.1	15.7
Weed mapping	15.4	7.9	19.6	56.1
Crop rotation advice	7.4	28.4	31.2	33.0
Field sprayer calibration	14.4	17.6	25.5	42.6
Planter calibration for insecticides	10.6	33.6	20.7	35.0
Custom application of pesticides	2.8	39.4	44.0	13.0
Computer programs to assist in pest management	11.7	5.6	22.0	60.7
Record keeping as required by the atrazine rule	1.4	44.9	20.4	33.0
Other	0.0	0.8	0.0	2.3

(*) NA = Not Availible
AU = Availible and am Using
ANU = Availible and Not Using
DK = Don't Know

Q35 **Has this supplier ever encouraged you to apply herbicides at rates below label recommendations:**

	AMA n=217	CON n=258	TOT n=491
YES	47.9	46.1	46.8
NO	52.1	53.9	53.2

Q36 **How does your primary supplier of agrichemicals learn about the needs and requirements of your farm operation:**

	AMA n=223	CON n=267	TOT n=508
Mail surveys	5.0	6.0	5.5
Farm visits	66.8	70.4	68.7
Casual, social contact	35.0	37.5	35.6
Over the counter discussions	61.9	65.2	63.8
Telephone conversations	56.5	58.4	57.1
County agricultural offices	10.3	9.0	9.4
My supplier generally doesn't know much about my farming operation	8.1	5.2	6.3
Don't know	2.7	5.2	4.3

Q37	Reasons why this is my primary agrichemical dealer:	AMA n=222	CON n=264	TOT n=504
	Assist in the identification of weeds and other pests	28.8	25.8	27.4
	Offers new products and services to be tried on my farm	9.5	9.5	9.5
	Offers quality products that have worked in the past	45.5	42.8	43.8
	Provides just what I ask for and does not try to push other products	32.0	33.3	32.9
	Provides information that can be trusted	37.4	39.0	38.5
	Helps me understand and meet req. of various laws and restrictions	17.1	19.3	18.5
	Offers products and service at a competitve price	48.2	53.1	50.6
	willingness to come to my farm to get detailed information on pest and nutrient problem	18.5	22.3	20.0
	Provides a reliable source of information on crop production	17.1	16.3	16.7
	Helps me credit on farm nutrients(legumes and manures)	5.0	5.7	5.4
	They are the closest agrichemical dealer to my farm	15.8	17.8	16.9
	They provide an annual rebate check based on my purchases	4.5	1.1	2.6
	I have know the people who work at the dealership most of my life	12.6	14.8	14.7

Q38 a	How much information on each of the following topics has this primary supplier of agrichemicals provided to you:	None	Little	Fair Amount
	AMA			
	Responsibilities under the atrazine rule	11.9	12.8	40.6
	Pesticide handling, loading, storage and disposal practices	14.3	14.3	46.1
	Non-atrazine herbicides	8.3	14.2	43.6
	Mechanical weed control	30.3	27.1	28.4
	Record keeping requirements under the atrazine rule	21.7	20.3	36.9
	Maximum allowable atrazine application rates	13.0	12.0	34.3

Q38 b	CON			
	Responsibilities under the atrazine rule	11.1	17.9	37.7
	Pesticide handling, loading, storage and disposal practices	11.8	23.2	36.6
	Non-atrazine herbicides	8.0	12.4	48.2
	Mechanical weed control	27.2	29.3	30.9
	Record keeping requirements under the atrazine rule	18.9	23.3	30.9
	Maximum allowable atrazine application rates	13.0	14.2	36.4

Q38 c	TOT			
	Responsibilities under the atrazine rule	11.3	15.2	39.3
	Pesticide handling, loading, storage and disposal practices	12.7	18.8	41.5
	Non-atrazine herbicides	7.9	13.2	46.1
	Mechanical weed control	28.6	28.0	29.6
	Record keeping requirements under the atrazine rule	20.0	21.7	34.1
	Maximum allowable atrazine application rates	12.7	12.9	35.5

ON FARM DRINKING WATER

Q39	What is the primary source of your household water:	AMA n=222	CON n=268	TOT n=508
	Private Well	97.7	97.8	97.8
	Public Supply	2.3	1.5	1.8

Q40	Which of the following precautions have you taken to protect your drinking water:	AMA n=181	CON n=213	TOT n=411
	Test for nitrates at least once a year	53.0	46.9	49.9
	Drink bottled water only	1.1	0.0	0.5
	Test for pesticides once a year	22.1	18.8	20.2
	Use home water treatment system	2.2	4.7	3.6
	Test for bacteria once a year	45.3	43.2	44.0
	Installed back-siphon prevention devices	30.9	31.1	29.9
	Other	17.7	18.8	18.5

Q41-43	Perceptions of water quality:	AMA n=222	CON n=266	TOT n=506
	How would you rate your drinking water:	1.37 (.053)	1.4 (.045)	1.4 (.760)
	How has the quality of your drinking water changed in the last 5 years:	0 (.028)	.086 (.027)	.046 (.020)
	Relitive to today, what will your drinking water be like in 5 years:	.009 (.040)	.053 (.034)	.030 (.030)
	reported value represents score on a (-2 to +2) scale.			

Q44a	Where is atrazine usually loaded into your field sprayer for application on your farm:	AMA n=185	CON n=235	TOT n=430
	Off farm facility	20.5	28.9	25.1
	In the field	34.1	35.7	34.9
	At the farmsted	45.4	35.3	40.0

Q44b	Is this loading area within 50 feet of the well that serves as your primary water source:	AMA	CON	TOT
	YES	85.2	88.2	86.0
	NO	14.8	11.8	14.0

Q45	Which of the following categories describes the surface of the loading site in Q44:	AMA n=148	CON n=166	TOT n=322
	Dirt / Grass	39.2	44.0	41.3
	Blacktop / Asphalt	9.5	6.0	7.5
	Concrete	11.5	13.3	12.1
	Gravel / Crushed Rock	39.9	36.7	39.1

FARM PLANNING

		AMA	CON	TOT
Q46 a	**Is any part of the land you operate or own currently in an Atrazine Management Area or Atrazine Prohibition Area:**	n=217	n=258	n=491
	No land I operate is in AMA or APA	10.1	28.7	20.4
	I don't know	11.5	17.9	15.1
	Yes, part or all my land is in a AMA	70.5	51.0	59.0
	Yes, part or all my land is in a APA	12.0	5.9	9.4

Q46 b	**If in AMA or APA, was any land planted to corn:**			
	YES	89.9	86.8	88.2
	NO	9.6	8.2	8.9

Q46 c	**If in AMA or APA, will any land be planted to corn in 1993 or 1994:**			
	YES	88.9	83.9	86.6
	NO	10.6	11.8	10.8

		AMA	CON	TOT
Q47	**Estimate the tillable acreage (owned or rented) of your farming operation in 92:**	n=217	n=261	n=494
	Tillable Acres mean(std dev)	393.7 (409.1)	384.8 (393.5)	386.2 (395.4)

		AMA	CON	TOT
Q48	**In 92, how many acres of the following did you operate:**	n=219	n=262	n=497
	Field Corn ____ Acres	233.9 (341.8)	220.0 (268.1)	223.9 (299.5)
	Soybeans ____ Acres	40.4 (102.7)	42.7 (79.3)	41.3 (89.8)
	Small Grains ____ Acres	22.0 (25.5)	25.2 (37.8)	23.8 (32.6)
	Canning Crops ____ Acres	17.8 (58.5)	10.4 (41.3)	13.5 (49.2)
	Alfalfa / Hay ____ Acres	76.9 (74.6)	78.2 (82.4)	77.9 (78.3)
	Pasture ____ Acres	24.1 (76.5)	24.6 (73.9)	25.1 (76.1)
	Set Aside ____ Acres	19.3 (72.7)	126.0 (20.3)	16.6 (56.5)

		AMA	CON	TOT
Q49	**What is the average corn yield of your farm operation:**	n=212	n=255	n=481
	Bushels / Acre	127.7 (20.2)	126.0 (20.3)	127.1 (20.2)
	Tons / Acre	23.5 (28.3)	10.0 (7.2)	14.7 (18.9)

		AMA	CON	TOT
Q50	**Gross Farm Income for 92:**			
	Gross Farm Income ($1000) mean(std dev)	146.9 (96.6)	138.5 (94.7)	142.4 (94.8)

		AMA	CON	TOT
Q51	**What percentage of gross farm income came from each of the following sources:**	n=169	n=179	n=358
	Dairy	39.0	38.9	39.0
	Livestock	19.3	18.3	18.9
	Cash Crops	28.0	30.0	28.5
	Government Programs	7.7	8.1	7.8
	Other	6.0	5.3	5.7

		AMA	CON	TOT
Q52	**How long have you managed your current farming operation:**			
	_____ Years mean (std. dev.)	21.6 (12.1)	21.9 (11.9)	21.8 (12.0)

Q53	What changes in your farming operation are you planning over the next five years:

		S	D	SS	S/I
Dairy	AMA	10.0	7.3	58.0	12.7
	CON	15.1	7.0	53.5	11.4
	TOT	12.7	7.5	55.0	12.1
Livestock	AMA	8.1	8.1	57.8	19.7
	CON	9.2	10.6	49.1	25.7
	TOT	8.6	9.1	53.3	22.7
Corn	AMA	5.3	12.6	66.0	14.6
	CON	6.0	8.4	67.3	16.7
	TOT	5.7	10.2	67.1	15.3
Soybean	AMA	6.0	5.4	47.0	26.2
	CON	8.6	3.2	44.9	26.2
	TOT	7.4	4.3	45.8	25.2
Forage	AMA	5.2	6.9	63.0	16.2
	CON	8.3	9.3	59.7	15.3
	TOT	6.9	8.4	61.0	15.4

S = Stop
D = Decrease
SS = Stay the Same
S/I = Start or Increase