



By electronic and certified mail

March 17, 2010

Gregg Regimbal
Supervisor, Pesticide Management Unit
Pesticide and Fertilizer Management Division
Minnesota Department of Agriculture
625 Robert Street North
Saint Paul, MN 55155-2538
Phone: (651) 201-6671
E-mail: gregg.regimbal@state.mn.us

Re: Minnesota Atrazine Special Registration Review

Dear Mr. Regimbald:

On behalf of the Natural Resources Defense Council ("NRDC"), and our over 1.2 million members and activists, approximately 25,000 of whom reside in Minnesota, we submit the following comments regarding Minnesota's Special Registration Review of the pesticide atrazine. These comments complement NRDC's national report, *Poisoning the Well*, on the impact of atrazine on surface and drinking water in the Midwest, including Minnesota. (Wu et al., 2009.) A copy of the report is enclosed for your review.

NRDC applauds the Minnesota Department of Agriculture, the Minnesota Pollution Control Agency, and the Minnesota Department of Health for undertaking this special registration review. As described below, atrazine is an endocrine disrupting chemical, used in Minnesota and throughout the Midwest. The pervasive and recurring detection of atrazine in surface and drinking waters in the United States has raised significant concerns over the ecological and human health effects of atrazine exposure. While Minnesota's efforts to review atrazine's registration in the State is laudable, the conclusions reached by the review itself, and the limited nature of the scientific evidence and data on which it is based, is flawed.

Minnesota's review does not adequately account for (and in many cases fails to consider entirely) the scientific evidence of atrazine's health and ecological effects, it fails to adequately assess the limited economic benefits that the use of atrazine confers on Minnesota farmers, and it does not fully explore alternative farming practices that can greatly reduce the use of pesticides. Moreover, Minnesota's review is based on a limited set of data, as well as a drinking water standard that continues to rely on running annual averages. The result is that spikes in atrazine concentrations, which appear in Minnesota, are effectively ignored. In light of these deficiencies, we recommend that Minnesota revise its review and expand its atrazine monitoring

programs. NRDC also continues to advocate for the complete phase out of atrazine in the United States, including Minnesota. Simply put, the benefits of this chemical simply do not outweigh its danger to our health and environment.

I. The Use of Atrazine Should be Phased Out In Minnesota

A. Atrazine is an endocrine disrupting chemical with adverse human health and ecological effects.

Atrazine is one of the most commonly used herbicides. Applied to soil before crop planting to selectively suppress the growth of broadleaf and grassy weeds, the United States applies an estimated 60 to 80 million pounds of atrazine active ingredient annually to corn, sugarcane, and sorghum crops. According to the Special Registration Review's Technical Assessment, between 22% and 41% of field corn acres (and as much as 62% of sweet corn acres) in Minnesota are treated with atrazine every year. (Tech. Asses., Cost and Benefits, pp. 1 – 2.) Atrazine is primarily manufactured by Syngenta Crop Protection, a Swiss-based company (formerly a unit of Novartis and, before that, CibaGeigy).

Because of its widespread use, and because it is typically applied in the spring before crops are planted and when rains are frequent, atrazine is often transported in runoff from fields to nearby surface waters. Indeed, atrazine is the most commonly detected pesticide in U.S. waters, present in more than 75% of stream samples and 40% of shallow groundwater samples in agriculture areas across the United States. (Gilliom et al. 2006.)

Atrazine is an endocrine-disrupting chemical. Numerous studies show that atrazine can have effects on human health, wildlife and entire ecosystems. Many of these studies are described in detail in the 2009 NRDC report *Poisoning the Well* (Wu et al., 2009.) More recent studies, described below, further confirm atrazine's potential adverse effects.

1. *Prenatal atrazine exposure may increase risk of poor birth outcomes and birth defects in infants.*

A study published in 2009 found a significant correlation between prenatal atrazine exposure and reduced birth weight. (Ochoa-Acuña et al. 2009.) The authors reviewed the birth records of over 24,000 babies born in Indiana, and then localized each birth to the particular community water system where the mother lived. By knowing the atrazine levels in the drinking water of each system, the authors reasonably presumed that each mother would be exposed to that level of atrazine during her pregnancy. Their analysis showed that the mothers having the highest atrazine in their tap water for the duration of the pregnancy (above 0.7 parts per billion (ppb)) also had the highest risk of having a baby with low birth weight, compared with the lowest exposed group (below 0.3 ppb). Small birth weight is associated with a greater risk of developmental delay, increased infant illness, and an increased risk for some diseases such as cardiovascular disease and diabetes. (de Bie et al. 2010.)

Another 2009 study that analyzed over 30 million births across the U.S. reported an increased risk of birth defects associated with mothers who became

pregnant between April and July, when pesticides in waterways are at their highest levels. (Winchester et al. 2009.) The authors reported that among the pesticides monitored in the waterways, the risk was most closely associated with atrazine contamination. While this study did not measure drinking water levels specifically, the fact that the risk is highest when conception is timed with peak pesticide contamination in rivers and streams raises red flags. In an earlier paper, researchers reported on a significant association between atrazine water contamination levels and birth defects in the gut wall of newborn babies in Indiana. (Mattix et al. 2007.) In fact, this study found that the rate of this particular birth defect is higher in Indiana than the rate across the country. Although there are many other water contaminants besides pesticides that are likely to cause reproductive harm, such as pharmaceutical waste, these would not be expected to show seasonal peaks like agrichemicals do.

While the Technical Report acknowledges these and other epidemiology studies of atrazine, it nonetheless concludes that “the weight-of-evidence from reviewed studies can be currently summarized as insufficient to establish causal relationships between atrazine exposure and certain adverse effects.” (Technical Assessment, Human Health Assessment, p. 11.) To the contrary, these studies suggest that atrazine is likely to contribute to birth defects and small birth weight babies, along with genetic and other environmental contaminants.

2. *Farmers who apply atrazine are exposed to unsafe levels of atrazine.*

Particularly at risk from atrazine exposure are workers, including farmers, who mix, load, and apply atrazine. Exposure can result from accidental spills and splashes onto the skin or clothing, or inhalation of fumes and small droplets when the chemical is being applied to the field. A recent study of Iowa farmers reported finding atrazine metabolites in the urine of farmers who had recently applied atrazine, proving that they had been dosed with the pesticide. (Bakke et al. 2009.) As the Technical Report itself notes, scientific studies have linked atrazine urine levels in farmworkers and rural men to reproductive effects, such as low sperm count and motility. (Swan et al. 2003; Swan 2006; Curwin et al. 2005.) Interestingly, the Iowa study—which the Technical Report does not cite—reported that the amount of pesticide in the urine was related to the amount applied to the field. As such, if Minnesota was to significantly reduce the amount of atrazine that can be applied (or phase out its use altogether, as we recommend) one immediate positive effect for Minnesota farmers would be reducing the contamination of their bodies.

3. *Atrazine can have widespread effects on wildlife and ecosystems.*

In addition to its possible human health effects, atrazine is also capable affecting entire aquatic ecosystems by killing algae and other aquatic plants that provide food and oxygen for aquatic animals. EPA has found that, at sufficiently high concentrations, these effects “may be severe due to the loss of up to 60 to 95% of the vegetative cover, which provides habitat to conceal young fish and aquatic invertebrates from predators. Numerous studies have described atrazine’s ability to inhibit photosynthesis, change community structure, and cause the mortality of aquatic flora at concentrations between 20 and 500 ppm.” (EPA 2006.)

Indeed, as noted by the Technical Assessment, researchers at Tulane University reviewed nineteen published scientific studies of atrazine effects to see what findings were common among the studies. They published their findings in early 2010, reporting similar effects of atrazine on the hormone and immune systems of freshwater aquatic wildlife species, including impaired immune function, increased infection rates, delayed metamorphosis, impaired sperm production, and altered gonad development. (Rohr et al. 2010.) Some of the detailed findings of their meta-analysis are:

- Atrazine reduced size at or near metamorphosis in 19 of 19 studies (responses were non-monotonic, meaning metamorphosis was sometimes delayed and sometimes accelerated in atrazine-exposed test animals);
- Atrazine reduced anti-predator behavior in 6 of 7 studies;
- Atrazine was associated with impaired immune function in 35 of 42 endpoints and with an increased infection in 13 of 16 endpoints; and
- Atrazine altered gonad development in 8 of 10 studies, and impaired gonad function by altering spermatogenesis in 2 of 2 studies, and altered sex hormone concentrations in 6 of 7 studies.

This kind of scientific consistency in results across a number of well-designed studies provides strong evidence that atrazine causes impaired endocrine and immune system function in exposed aquatic wildlife.

4. *Experimental evidence further reinforces atrazine's endocrine disrupting effects on aquatic species.*

In early 2010 the lab of well-known frog expert, Dr. Tyrone Hayes, published a startling study, reporting that 10 percent of male frogs that were born and raised in water contaminated with 2.5 ppb of atrazine grew up with female sex characteristics, including reduced levels of male testosterone hormone, reduced sperm levels, and decreased fertility. (Hayes et al. 2010.) Even more startling, the atrazine-treated males showed female mating behavior, attracted normal males, mated with them, and produced eggs that grew into adult frogs. Because of its shocking nature, these scientific findings were widely reported in the news, including *USA Today* and *CNN*. Not surprisingly, Syngenta scientists strongly criticized the study.¹ However, Hayes' findings are in general agreement with other reports in the scientific literature (summarized below) that show the hormone-disrupting effects of atrazine and cannot be discounted.

¹ USA Today. Tap water contaminant castrates frogs. Liz Szabo. March 1, 2010. http://www.usatoday.com/tech/science/2010-03-02-1Aatrazine02_ST_N.htm; CNN.com Weed killer 'castrates' male frogs, study says. Azadeh Ansari. March 1, 2010. <http://www.cnn.com/2010/TECH/science/03/01/pesticide.study.frogs/index.html>.

Other significant scientific studies published in 2009 provide laboratory evidence that atrazine interferes with normal hormone function:

- Even a single dose of 200 mg of atrazine per kg body weight (mg/kg) given to male rats caused a measurable increase in steroid hormone release within 15 minutes after dosing. (Laws et al. 2009.)
- Lab rats fed atrazine-contaminated feed for 1 or 2 weeks (120 mg/kg, 200 mg/kg) had a dose-dependent reduction in sperm number and impaired daily sperm production. (Abarikwu et al. 2009.)
- Rats fed atrazine-contaminated feed (50 mg/kg, 200 mg/kg) for 25 days had a significant dose-dependent reduction in steroid production in the Leydig cells of the testes. (Pogrmic et al. 2009.)
- Rats treated for 5 months with atrazine-laced drinking water (30 or 300 µg/kg per day) had associated insulin-resistance leading to obesity. (Lim et al. 2009.)

Yet the Technical Assessment does not discuss, much less cite, any of this work. Indeed, the Assessment does not even cite earlier published studies by Hayes, in which he found that concentrations as low as 0.1 ppb have been shown to alter the development of sex characteristics in male frogs, resulting in male frogs with female sex characteristics, hermaphroditism, and the presence of eggs in male frog testes. (Hayes et al. 2002.)

Finally, in an interesting study of the effects of atrazine and other pesticides in mixtures, one laboratory reported that when tiger salamander larvae were raised for 2 weeks in water containing atrazine (20 or 200 ppb) or chlorpyrifos (2, 20, or 200 ppb) no increase in deaths was observed. When the larvae were exposed to the combination of atrazine and chlorpyrifos together, however, there was a significant increase in larval deaths from increased viral infection and disease, suggesting that the treatment critically impaired immune function. (Kerby et al. 2009.) Again, this study is not cited by the Technical Assessment.

Despite this evidence, and the discretion to set more restrictive and protective standards in accordance with state and federal law, the Special Registration Review recommends that the state continue to rely on EPA's and the State's existing drinking water and water quality standards for atrazine. This conclusion does not reflect an objective view of the weight of the scientific evidence. By simply adopting as a default the State and federal government's current standards, Minnesota has abrogated its responsibility to adopt measures that would be more protective of human and environmental health.

B. Atrazine Has Limited Economic Benefits and alternative farming practices can greatly reduce pesticide use.

The need to further restrict, and eventually phase out, the use of atrazine in Minnesota is further reinforced by the chemical's extremely limited economic benefits. Unfortunately, the Technical Assessment misstates much of the economic evidence in

this regard and ignores the availability of farming techniques that can reduce overall pesticide use in the State.

Most egregious is the Technical Assessment's discussion of a 2007 paper by Professor Frank Ackerman evaluating the economic benefits of atrazine. The Technical Assessment states that:

Ackerman's combined assessment of Coursey, Fawcett, and EPA states that these economic studies roughly agree that the cost of banning atrazine is between \$26 – 28 per acre.

(Tech. Asses., Costs and Benefits, p. 4 of 8.)

This is a gross mischaracterization of Ackerman's work and calls into question the objectivity of the Technical Assessment's entire cost/benefit analysis. In fact, Ackerman's review was critical of all three of these studies. He states:

However, these estimates are deficient in at least two respects. EPA, Coursey, and Fawcett do not include the full range of economic impacts...some of which represent increases in farm income, partially or wholly offsetting the losses. ... Second, the EPA and Coursey studies, despite 2002 and 2007 publication dates, rest on much older (and inadequately cited) data on corn yields.

(Ackerman 2007, p. 444.) More specifically, Ackerman notes that in all three studies "no estimate is included for reduction of corn acreage, price increases, or revenues from other crops that might replace some corn acreage." (*Id.*, p. 440.) Ackerman is particularly critical of Coursey's study and concludes that both Coursey and EPA suffers from "double counting," artificially raising their estimate of yield losses from the discontinuation of atrazine use. None of this is discussed by the Technical Assessment.

The Technical Assessment also fails to discuss another cost/benefit study, conducted by the U.S. Department of Agriculture in 1994.² As Ackerman points out in his review, this assessment is more complete and estimates a dramatically lower yield and dollar-value losses associated with ceasing atrazine use than any of the other studies cited by the Technical Report. For example, whereas EPA, Fawcett, and Courey predict yield losses of 6.4%, 3.1-3.8%, and 4-7.6%, respectively, the USDA study predicts yield losses of only 1.19%. (Ackerman 2007.)

Additionally, the Technical Assessment contains no discussion of Ackerman's central finding, that despite a ban on the use of atrazine in Italy and Germany (both corn-producing nations) since 1991 neither country has recorded any significant economic effects. Indeed, there was "no sign of [corn] yields dropping in Germany or Italy after 1991, relative to the U.S. yield—as would be the case if atrazine were

² Oddly, this report is referenced as "[10]" under the "Works Cited" section of the cost/benefit report of the Technical Assessment (Tech. Asses., Costs and Benefits, p. 7 of 8) but is never actually cited in the report itself.

essential” and “[f]ar from showing any slowdown after 1991, both Italy and (especially) Germany show faster growth in harvested areas after banning atrazine than before.”

Based on this analysis, Ackerman concludes that if “the yield impact is on the order of 1%, as USDA estimated, or close to zero, as suggested by the newer evidence discussed here, then the economic consequences [of banning atrazine] become minimal.” (Ackerman 2007, p. 444.) Again, this conclusion is left unaddressed by the Technical Assessment.

Finally, the Technical Assessment fails to include a robust discussion of alternative farming practices. The majority of the Assessment’s section on atrazine alternatives is confined to a discussion of the availability and efficacy of other pesticides. Under a small subsection titled “*Nonconventional Alternatives*” the Technical Review briefly discusses organic farming, but concludes that “a detailed discussion of the agronomic issues associated with organic v. conventional corn production in Minnesota is beyond the scope of this pesticide-specific technical review.” (Tech. Asses., Costs and Benefits, p. 5 of 8.)

What the Technical Assessment lacks is a discussion of how alternative farming practices, short of full-blown organic production, can greatly reduce the use of pesticides or an assessment of the economic and health consequences of using these techniques to further reduce atrazine application in Minnesota. These techniques include: the use of cover crops (Liebman and Davis 2000); the use of rotary hoes after weed seeds have germinated, but before weed emerge (Franti et al. 1996); delaying half of the fertilizer used on corn until after the ears emerged, depriving weeds of nutrients during key periods of growth (NRC 2000); alternating rows of different crops (Liebman et. al. 2008); and shifting from a two-year corn/soy rotation, to a three- or four-year rotation that adds species such as alfalfa and oats (Westerman et al. 2005.). Individually and collectively, the available literature shows that these techniques can greatly reduce the need for pesticide application. None of these studies, however, are discussed or evaluated by the Technical Report.

II. Minnesota’s monitoring and compliance data is limited and may be misleading.

The Minnesota Department of Health (MDH) conducted the Technical Assessment’s Human Health Assessment. In its report, the MDH states:

For the general population, the oral route via drinking water is the dominant exposure pathway for atrazine and its metabolites based on atrazine’s use patterns, persistence and mobility in the environment, and its occurrence in Minnesota surface and groundwater.

(Tech. Asses., Human Health Assessment, p. 13.)

As such, it is important that the assessment of atrazine contamination in drinking water is based on adequate and appropriate monitoring and sampling data. Unfortunately, the data that the Technical Assessment relies on to make its drinking water exposure assessment is neither. In fact, the limitations with the data likely

underestimate the extent to which Minnesota residents are exposed to atrazine through drinking water. As a result, the Special Registration Review's conclusion that there is "no risk of concern" due to atrazine exposure from drinking water is unfounded, and the decision to re-register atrazine is not protective of human health.

The Technical Assessment bases its drinking water assessment on data that community water systems are required to take to monitor their compliance with the Safe Drinking Water Act (SDWA), 42 U.S.C. §§ 300f *et seq.*. According to the Assessment, depending on various conditions, community water systems are required to take "compliance samples" for atrazine anywhere from four times per year to once every three years. (Tech. Asses., Human Health Assessment, p. 20.)

These compliance samples are used to show that the levels of atrazine in a water system do not exceed 3 ppb on a rolling annual average. As explained below, more frequent sampling – such as once a week during the spring and summer seasons – show that Minnesota should be much more concerned about atrazine contamination of drinking water.

A. Frequent sampling shows widespread atrazine contamination of drinking water.

NRDC's report, *Poisoning the Well*, presented some startling findings. (Wu et al., 2009.) This report brings to light the fact that atrazine contaminates drinking water sources far more frequently and at far higher concentrations than expected. More problematic, we found that there are drinking water systems that are technically in compliance with the SDWA, but that have concentrations that actually exceed the federal standard when more frequent sampling is conducted.

The report is based on our analysis of monitoring data taken from 139 public water systems representing more than 14,000 samples between 2003 and 2004. These samples were taken once a week during the atrazine use season and once every two weeks during the rest of the year—much more frequently than typical compliance samples. This sampling showed a disturbing trend: extremely high spikes of atrazine concentrations in drinking water are completely missed by compliance sampling. Some of these spikes are so high that some systems' rolling annual averages actually exceed the U.S. Environmental Protection Agency's Maximum Contaminant Level (MCL) of 3 ppb, even though they were technically in compliance. This occurs when only four samples are taken throughout the whole year, or worse still, one sample is taken every one to three years—rendering the likelihood of taking a sample during a spike in atrazine to nearly zero. Therefore, showing compliance with the MCL under the infrequent monitoring plan does not necessarily mean a system's annual average concentration of atrazine is actually below 3 ppb.

While no systems in Minnesota participated in the program from which we received drinking water data, the experience of the 10 states that were examined underscores the high likelihood that any state using atrazine extensively would see the same results—that is, annual averages of atrazine in drinking water that actually do exceed the federal MCL and dangerously high spikes of atrazine during the spring and summer months. In other words, the sampling regime for showing compliance with

legal standards is not protecting human health from the harmful adverse effects from atrazine exposure.

B. The MDH improperly relies on very limited, infrequent sampling data.

According to the Technical Assessment, there are 961 active community water systems in Minnesota. The Minnesota Department of Health, however, only had data from 57% of the systems – or 544 systems – to use in its analysis. A total of 2,782 samples were taken from the 544 community water systems with data, which averages to about 5 samples taken per system. The Assessment indicates that these samples were taken between 2000 and 2008, or over a period of 9 years. *This averages out to fewer than one sample per system per year.* Samples taken a few times a year, or once a year, or even once every three years, cannot be used to reliably determine that atrazine in drinking water is of no concern. As shown in *Poisoning the Well*, dangerously high spikes of atrazine can occur in drinking water for just a few weeks out of the year. If a system samples only once a year or a few times a year, it is very likely that that sample will miss the spike entirely and give the false impression that there is little to no atrazine in the water.

The Technical Report acknowledged limitations with the data due to the frequency of the sampling. It notes: “The ability to fully assess concentration patterns or time trends is limited due to infrequent sampling as a result of waivers granted by the state,” which our report supports. (Tec. Assess., Human Health Assessment, p. 19) However, the Technical Report continues, “[s]ince waivers are justified by monitoring data showing low atrazine contamination potential, the data are somewhat positively (conservatively) biased with respect to the CWS [community water systems] which are sampled.” (*Id.*) This is wrong. Waivers that are justified by monitoring data showing low atrazine contamination potential are not conservatively biased. As shown in our report, infrequent monitoring data will always skew towards *not* finding atrazine detections, and therefore, the systems granted waivers may be just as susceptible to high atrazine spikes as are other systems.

In short, the Technical Assessment has greatly underplayed the limitations of the drinking water data from Minnesota. Its reliance on this data is misplaced. Based on the experience of the Midwestern states that use atrazine and have conducted frequent sampling of their drinking water, the Technical Assessment’s conclusion that Minnesota’s sampling data adequately supports a finding that there is no risk of concern for atrazine exposure from drinking water is unfounded. The State should reevaluate its conclusions and, instead, consider the distinct likelihood that atrazine is contaminating the drinking water of Minnesota at potentially dangerous levels. In addition, Minnesota should take immediate steps to increase the frequency of its atrazine monitoring regime.

III. Conclusion

Minnesota’s Special Registration Review of atrazine is a welcome development. For years the scientific evidence of atrazine’s potential harm to human and ecological health has risen, while the evidence of its economic benefits has been increasingly called into question. Sadly, however, as written Minnesota’s Special Registration Review often fails to come to grips with or, in many cases, even discuss

some of the most important scientific evidence available. To make matters worse, Minnesota's Review relies on an extremely limited set of drinking water data. As a result, the Review's basic conclusion that the State's current standards sufficiently protective of the public and the environment, as well as justified by the economic benefits of atrazine's use, is fundamentally flawed.

Thank you for considering these comments.

Very truly yours,

A handwritten signature in black ink, appearing to read "Andrew Wetzler". The signature is written in a cursive style with a large initial 'A'.

Andrew Wetzler, J.D.
Jennifer Sass, Ph.D.
Mae Wu, J.D.

Literature Cited

Abarikwu SO, Adesiyun AC, Oyeloja TO, Oyeyemi MO, Farombi EO. Changes in Sperm Characteristics and Induction of Oxidative Stress in the Testis and Epididymis of Experimental Rats by a Herbicide, Atrazine. *Arch Environ Contam Toxicol*. 2009 Aug 12.

Ackerman F. The economics of atrazine. *International Journal of Occupational and Environmental Health*. 2007; 13(4):437–45.

Bakke B, De Roos AJ, Barr DB, Stewart PA, Blair A, Freeman LB, Lynch CF, Allen RH, Alavanja MC, Vermeulen R. Exposure to atrazine and selected non-persistent pesticides among corn farmers during a growing season. *J Expo Sci Environ Epidemiol*. 2009 Sep; 19(6):544-54.

Curwin BD, Hein MJ, Sanderson WT, Barr DB, Heederik D, Reynolds SJ, Ward EM, Alavanja MC. Urinary and hand wipe pesticide levels among farmers and nonfarmers in Iowa. 2005. *J Expo Anal Environ Epidemiol*. 2005_(Nov); 15(6): 500–8.

de Bie HM, Oostrom KJ, Delemarre-van de Waal HA. Brain development, intelligence and cognitive outcome in children born small for gestational age. *Horm Res Paediatr*. 2010; 73(1):6-14.

EPA 2006. Atrazine RED. April 2, 2006. Docket EPA-HQ-OPP-2003-0367. Page 103. Available at: http://www.epa.gov/oppsrrd1/REDs/atrazine_combined_docs.pdf .

Franti TG, Roeth FW, Klein RN, Holshouser DL, Christiansen AP, Schild JA, Zoubek GL. Agricultural Management Practices to Reduce Atrazine in Surface Water. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. 1996. Available at: <http://www.p2pays.org/ref/09/08380.htm>.

Hayes TB, et al. Atrazine-induced hermaphroditism at 0.1 ppb in American leopard frogs (*Rana pipiens*): laboratory and field evidence. *Environ Health Perspect*. 2002; 111:568–575.

Hayes TB, Khoury V, Narayan A, Nazir M, Park A, Brown T, Adame L, Chan E, Buchholz D, Stueve T, Gallipeau S. Atrazine induces complete feminization and chemical castration in male African clawed frogs (*Xenopus laevis*). *Proc Natl Acad Sci USA*. 2010 Mar 9; 107(10):4612-7.

Kerby JL, Storfer A. Combined effects of atrazine and chlorpyrifos on susceptibility of the tiger salamander to *Ambystoma tigrinum* virus. *Ecohealth*. 2009 Mar; 6(1):91-8.

Laws SC, Hotchkiss M, Ferrell J, Jayaraman S, Mills L, Modic W, Tinfo N, Fraitas M, Stoker T, Cooper R. Chlorotriazine herbicides and metabolites activate an ACTH-dependent release of corticosterone in male Wistar rats. *Toxicol Sci*. 2009 Nov; 112(1):78-87.

Liebman M, Davis AS. Integration of soil, crop and weed management in low-external-input farming systems. *Weed Res.* 2000; 40:27–47.

Liebman M, Gibson LR, Sundberg DN, Heggenstaller AH, Westerman PR, Chase CA, Hartzler RG, Menalled FD, Davis AS, Dixon PM. Argomic and economic performance characteristics of conventional and low-external-input cropping systems in the central corn belt. *Agronomy J.* 2008; 100: 600–610.

Lim S, Ahn SY, Song IC, Chung MH, Jang HC, Park KS, Lee KU, Pak YK, Lee HK. Chronic exposure to the herbicide, atrazine, causes mitochondrial dysfunction and insulin resistance. *PLoS One.* 2009; 4(4):e5186.

Mattix KD, Winchester PD, Scherer LR. Incidence of abdominal wall defects is related to surface water atrazine and nitrate levels. *J Pediatr Surg.* 2007 Jun; 42(6):947-9.

National Research Council. Professional Societies and Ecologically Based Management. Proceedings of a workshop. Washington, DC. National Academies Press. 2000.

Ochoa-Acuña H, Frankenberger J, Hahn L, Carbajo C. Drinking-water herbicide exposure in Indiana and prevalence of small-for-gestational-age and preterm delivery. *Environ Health Perspect.* 2009 Oct; 117(10):1619-24.

Pogrmic K, Fa S, Dakic V, Kaisarevic S, Kovacevic R. Atrazine oral exposure of peripubertal male rats downregulates steroidogenesis gene expression in Leydig cells. *Toxicol Sci.* 2009 Sep; 111(1):189-97.

Rohr JR, McCoy KA. A qualitative meta-analysis reveals consistent effects of atrazine on freshwater fish and amphibians. *Environ Health Perspect.* 2010 Jan; 118(1):20-32.

Swan SH, Kruse RL, Liu F, Barr DB, Drobnis EZ, Redmon JB, Wang C, Brazil C, Overstreet JW, Study for Future Families Research Group. Semen quality in relation to biomarkers of pesticide exposure. *Environ Health Perspect.* 2003; 111:1478–84.

Swan SH. Semen quality in fertile US men in relation to geographical area and pesticide exposure. *Int J Androl.* 2006; 29:62–8.

Westerman P, Liebman M, Menalled FD, Heggenstaller AH, Hartzler RG, Dixon PM. Are many little hammers effective? Velvetleaf (*Abutilon theophrasti*) population dynamics in two- and four-year crop rotation systems. *Weed Science.* 2005; 53:382–392.

Winchester PD, Huskins J, Ying J. Agrichemicals in surface water and birth defects in the United States. *Acta Paediatr.* 2009 Apr;98(4):664-9.

Wu M, Quirindongo M, Sass J, Wetzler A. Poisoning the Well: How the EPA is ignoring atrazine contamination in surface and drinking water in the central United States. Report of the Natural Resources Defense Council (NRDC). August, 2009. Available at: <http://www.nrdc.org/health/atrazine/files/atrazine.pdf>.