Recommended Cropland Policy on Banning of

Glyphosate containing herbicide products:

Submitted by Richard Andrews, Boulder county resident

Original report from October 2011 submitted to Cropland Policy Advisory Committee, POSAC and the Boulder County Board of Commissioners; updated February 28, 2016 for the public hearing on revisiting of Boulder County Cropland Policy; all 2016 updates are noted in this red font.

Boulder County Parks and Open Space lands should ban the use of all pesticides containing glyphosate herbicides on its lands, including croplands, rangelands and other locations. The case for a ban of glyphosate, was justified in 2011, and has now become urgent.

Urgent Action Requested:

An immediate ban on the use of glyphosate containing herbicides on all Boulder county properties by Boulder County employees, contractors and lessees is recommended based upon overwhelming substantial new medical and environmental evidence of major harms to human health, and ecological negative impacts that has been revealed since the 2011 version of this report.

Summary Rationale for Proposed Glyphosate Ban:

The herbicide glyphosate (N-phosphonomethyl glycine) is widely used around the world, including on Boulder County open space crop and rangelands, as well as in many other situations.

Glyphosate is in fact the largest volume herbicide in use today. It rose from less than 10 million pounds in 1992 for USA agriculture to approaching 300 million pounds in the most recent officially reported USDA data. US farmland applications of glyphosate active ingredient since 1974 is over 1.6 billion kilograms (3.5 billion pounds). Two thirds of that total volume of glyphosate applied in the U.S. from 1974 to 2014 has been sprayed in the last ten years, due to the enormous growth over the last two decades in U.S. croplands planted to glyphosate resistant-genetically engineered (HR-GE) crops, including corn, soybeans, sugar beets, cotton, canola, and other crops (47).

Glyphosate has been claimed to be safe by its manufacturers for decades, but a growing body of independent scientific peer reviewed literature has shown otherwise, both with respect to negative environmental and human health effects. Claims that glyphosate has short persistence in the environment , largely based on its binding with clay in soils, have been proven false. The primary metabolic degradation product of glyphosate is AMPA (aminomethyl phosphonic acid) which is also toxic to plants, is persistent and extremely mobile in the environment. Furthermore studies have found that the toxic effects are glyphosate can reoccur in subsequent years due to the carryover in soils and plant residues, reversible release of adsorbed glyphosate from soil particles triggered by phosphorus fertilization, and desorption processes, making it available for plant uptake and negative/toxic effects, even in subsequently planted crops, and in releases to the aqueous environment.

Glyphosate has been claimed to be beneficial as a companion to genetically modified crops that are designed to be resistant to glyphosate toxicity while the pesticide is deadly to weeds. Glyphosate is used with all of the currently approved GE crops on Boulder County Open Space croplands, as well as in many other agricultural applications including desiccant uses on non-resistant crops just prior to harvest (67).

But recent research increasingly documented in peer reviewed science journals is revealing the numerous negative effects of glyphosate on farming systems:

- plant/crop nutrition (particularly disrupting trace element uptake),
- upsetting soil microbiological diversity and health,
- stimulation of food crop and animal feed pathogens and mycotoxins,
- drag on crop yields over long term use, and
- enhancement of super weed evolution.

Of extreme importance is the growing body of scientific evidence of the toxic effects of glyphosate on humans and other animals. There is very recent research published indicating that glyphosate and its many formulations is a causative agent for:

- birth defects, notably brain and facial/cranial abnormalities including microcephaly
- developmental disruptions/delays,
- endocrine disruption disorders
- reproductive defects,
- carcinogenicity expressed such as non-Hodgkin lymphoma and leukemia,
- chronic kidney disease, plus genotoxic DNA effects. (23)(24)(25)(27)(28)(29)(30)(31)(32)(33)(34)(35)(36)

The dramatic rise in the incidence of these diseases correlates with high confidence with the enormous growth in the use of glyphosate during the period since the introduction of glyphosate resistant genetically engineered crops (41)(42)(43)(44)(45). Linkages since 2011 have pointed to glyphosate as a causative chemical agent for the dramatic rise in incidence of many human diseases and disorders:

- autism spectrum
- gut microbiome dysfunction and related obesity, diabetes, inflamatory bowel, lipoprotein metabolism disorder, etc.
- chronic kidney disease, acute kidney failure, end stage renal disease
- stroke, hypertension
- Alzheimer's, senile dementia, Parkinson's
- Cancers of thyroid, liver, bladder, pancreas, kidney and myeloid leukaemia

A long list of highly respected worldwide medical professionals and scientists have just issued a concensus statement that glyphosate based herbicides (GBHs) are a major risk and need very serious priority review by such health agencies as Center for Disease Control and Prevention (46). They conclude*:*

1. *GBHs are the most heavily applied herbicide in the world and usage continues to rise.*
2. *Worldwide, GBHs often contaminate drinking water sources, precipitation and air, especially in agricultural regions.*
3. *The half-life of glyphosate in water and soil is longer than previously recognized.*
4. *Glyphosate and its metabolites are widely present in the global soybean supply.*
5. *Human exposures to GBHs are rising.*
6. *Glyphosate is now authoritatively classified as a probable human carcinogen.*
7. *Regulatory estimates of tolerable daily intakes of glyphosate in the United States and European Union are based on outdated science.*

In March 2015, published in the UK medical journal The Lancet-Oncology (39), the International Agency for Research on Cancer (IARC), a branch of the World Health Organization (WHO), issued a finding of glyphosate being a probable human carcinogen (Class 2A carcinogen), and a full IARC Monograph report Number 112 detailing this finding was issued later in the year (40).

A great deal of medical science and toxicology research has been published in peer reviewed journals since this review about glyphosate was first written for the Cropland Policy Advisory Group and the Boulder County Commissioners in 2011. Some of that growing recent literature will be reviewed in subsequent sections of this literature overview document.

Published research from Canada has found glyphosate and AMPA in women, and also found glufosinate and its degradate, closely related herbicides to glyphosate, in both pregnant women and their fetuses (35). Research from France has found that glyphosate is toxic to human placental cells (29)(30)(33). Numerous clinical studies with laboratory test animals have found similar adverse health effects.

Unbelievably glyphosate and its toxic metabolites have never been monitored in foods by USA food safety regulatory agencies (FDA, USDA, EPA) (with one minor exception), but these toxins have nevertheless been sampled and analyzed by numerous other foreign health agencies and independent academic researchers and independent bodies. The U.S. Government Accountability Office (GAO) chastised these U.S. federal agencies in 2014 for this failing among other significant deficiencies in food safety monitoring (66). Other foreign agencies and non-governmental studies and findings indicate glyphosate contamination occurrences in many foods, often above maximum residue limits (MRLs) particularly those foods made from genetically engineered glyphosate resistant (HR GE) crops such as soybeans, and corn. Glyphosate residue are also being found in other crops, notably small grains, where glyphosate is increasingly being used as a harvest *burn-down* desiccant, applied immediately prior to harvest. And these HR GE crops are now dominating both animal feeds and human foods in the USA.

Glyphosate use in agriculture is heavily based upon convenience to the farmer to facilitate reduced trips to fields for weed management, but the near and long term risks simply are not judged to be worth the short term and diminishing benefits of ease of farming, particularly when considering the major concerns about impacts to public health and the environment. All of these negative effects warrant elimination of the use of glyphosate on the public lands of Boulder County. To do otherwise is incompatible with environmental stewardship and sustainable agricultural practices, and certainly out of a sense that human health and production of the highest quality of safe foods must be the paramount factor.

Background Literature Review:

Glyphosate Herbicide (aka "Round Up" and other tradenames) –

Since the first edition of this review was provided to Boulder County in 2011, there has been an explosion of scientific literature on the subject of glyphosate. An overview of the interactions and effects of glyphosate with crop physiology, nutrition and diseases of plants, and ramifications to agricultural sustainability is provided in the following literature review. This review also cover aspects of environmental contamination from glyphosate, non-target species effects, human health impacts, food quality contamination, and agricultural economic impacts. A great deal of additional science has evolved on the matters of the enhanced toxicity of actual formulations and mixtures of pesticides on toxic effects.

The following scientific review focuses on the most recent research and primarily includes peer reviewed and published science. It also relies mostly on science from sources that have no apparent or discernable ties to the chemical manufacturers of glyphosate that could potentially bias the results, representations, and interpretations.

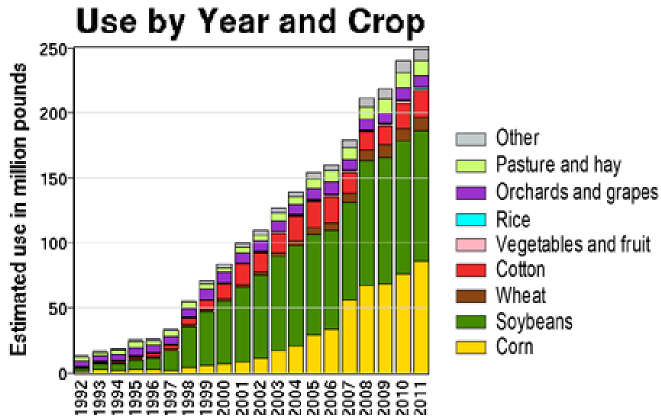
Use Rate Trends of glyphosate herbicides -

The agricultural chemical glyphosate, also known by the tradename *Round Up* in specific formulations and by numerous other tradenames by other manufacturers, is the most widely used herbicide ever (1)(47). It is advertised as generally benign to non-target species and with short environmental half life. But it has recently been shown in scientific evidence, some published by long silent corporate insider research scientists, that its use has undesirable consequences.

Glyphosate agricultural use in the U.S. rose from approximately 3 million pounds per year in 1990 to 250 million pounds in 2014, the most recent published data (47). Non-agricultural uses rose from 2.4 million pounds in 1990 to 12 million pounds in 2014. Nearly 2/3 of total use of glyphosate in the U.S. since 1974 has occurred in just the last 10 years, 90+% in agricultural uses coincident with the domination of GE crops, including glyphosate resistant corn, soybeans, cotton, sugar beets, and others.

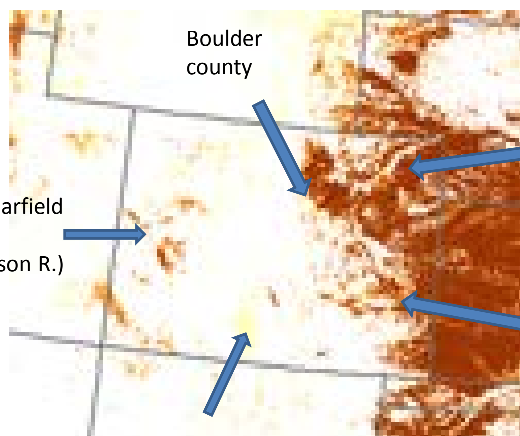
The first deregulated herbicide resistant genetically engineered crops in the U.S. occurred in 1995, with corn, soybeans and cotton. These were engineered to be resistant to glyphosate, and their introduction stimulated the rise in the use of glyphosate dramatically. Subsequent HR-GE crops, canola, further stimulated this rise in demand and use of glyphosate. The following graph of glyphosate use by crop and year illustrates and clearly shows these steps as GE crops are introduced and as the seed companies consolidate their control over the seed available to farmers. Corn and soybeans continue to dominate the induced demand for glyphosate. (Source: USGS mapping and USDA databases)

Glyphosate Herbicide (Round Up)Use

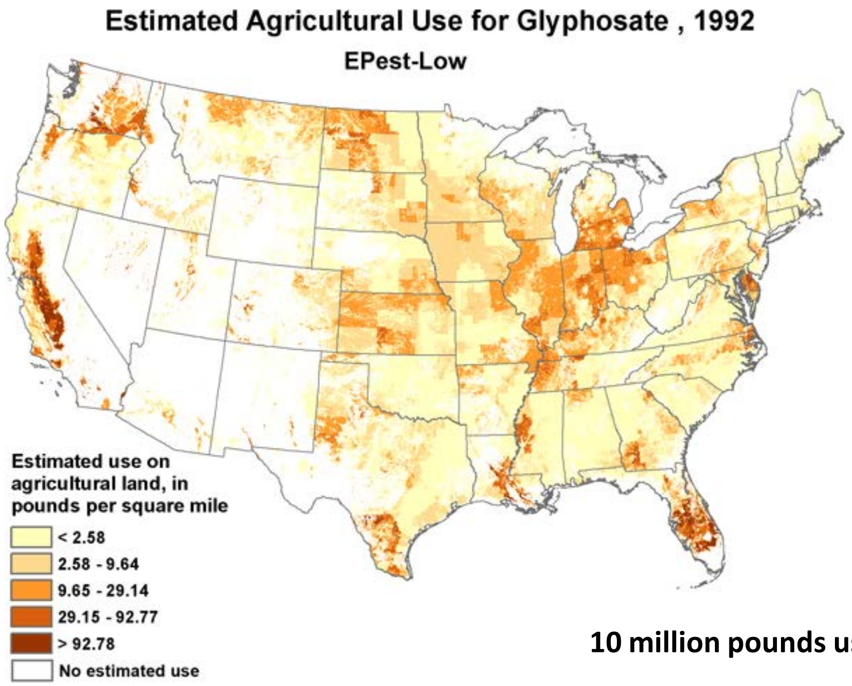


The following maps from U.S. Geological Survey and U.S. Department of Agriculture (NASS data bases) illustrate the dramatic rise in the use of glyphosate since the introduction of genetically engineered crops in the early 1990s.   The first map covers Colorado, the other two are for the U.S. in 1992 and 2011, respectively.

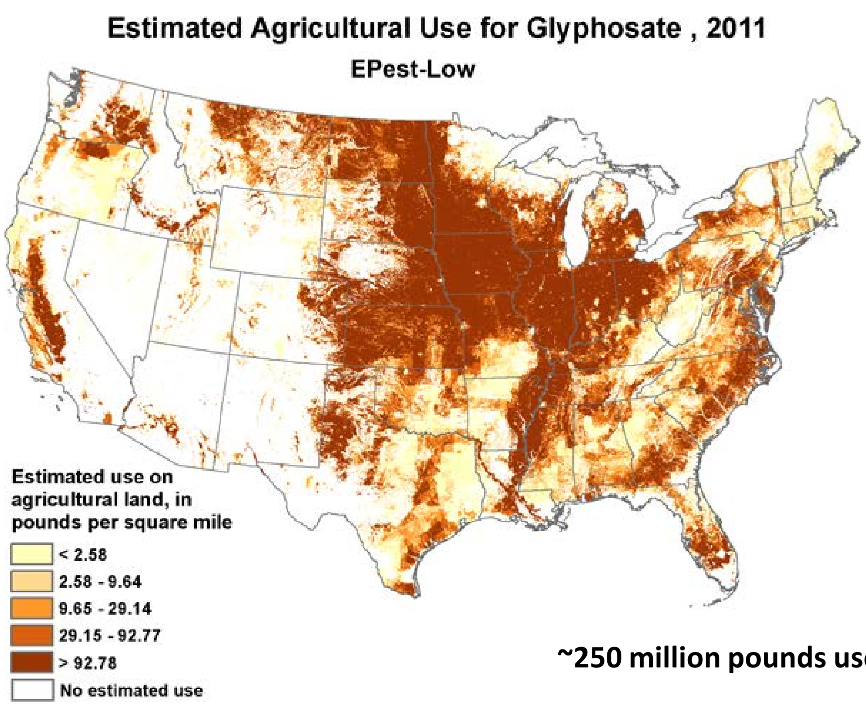
Glyphosate Use Patterns in Colorado   2011



Major crop uses: corn, potatoes, wheat, barley, pasture/hay, sugar beets used with many others (vegetables, fruits, etc.)



10 million pounds used



~250 million pounds used

Effects of Glyphosate on Crop Nutrition and Crop Health -

In 2009 Yamada, Kremer, Carmargo e Castro and Wood (2) provided an overview assessment of the effects of glyphosate interactions with physiology, nutrition and diseases of plants, and consequent threats to agricultural sustainability in a special edition of European Journal of Agriculture. In a companion paper, a negative consequence to crop health of glyphosate reported by Zobiole et al (3) is a decrease in soybean crop chlorophyll and photosynthetic activity, and related transpiration and stomatal conductance. They also observed significant decrease in macro and micro nutrients in leaf tissue with glyphosate treated plants, lower in the herbicide resistant (HR) plants than non-HR plants. Reduced biomass is observed in both above and below ground plant tissues in all glyphosate treated plants. Similarly, Bott et al (4) observed negative effects on zinc and manganese status in glyphosate treated soybeans. Glyphosate also inhibited root biomass production and elongation and lateral root development.

Zobriole, Kremer et al (16) have reported on the comparison of first generation (RR1) and second generation (RR2) genetically modified soybean cultivars, effects of growth stage and rates of glyphosate application, plus no glyphosate controls with these cultivars. They measure chlorophyll content, nodulation, biomass and nutrient accumulation. Overall conclusions were that RR2 did not improve yield indicating measures compared to RR1. Glyphosate significantly decreased chlorophyll content vs. control and reduction was more pronounced as rate increased and application was delayed during plant growth; observed chlorotic symptoms may relate to decreased photosynthetic rates due to glyphosate damage, potentially exacerbated by immobilization of Mg and Mn being chelated by glyphosate. These observations are consistent with Cakmak et al (18), Zablowtowicz and Reddy (17), and Zobriole et al (3). So the conclusion one draws is that even with genetically modified crops designed to be resistant to glyphosate, its use creates negative consequences to key indicator parameters of plant health and nutrition. In other words glyphosate actually injures the GMO crops it is designed to be used with.

Numerous researchers have in recent years discovered that glyphosate and its metabolites can interact with trace elements such as manganese, magnesium, zinc, iron, and nickel in the soil and inhibit their availability for plant uptake. Some of the elements are key to plant health, notably photosynthetic activity, root development, etc. Bailey et al (37) reported on this in 2002, Bernards et al (38) in 2005, and many others.

As long ago as 1980, USDA researcher Robert Hoagland (68) observed effects of glyphosate and its metabolites on natural plant phenolic compounds such as activity alterations of phenylalanine ammonia-lyase, growth performance, and protein, chlorophyll and anthocyanin levesl in soybean seedlings. Negative plant performance effects included inhibition of growth and root elongation. The primary glyphosate metabolite, AMPA, also exhibited inhibitory effects on phenylalanine. Glyphosate also significantly decreased total chlorophyll. Unfortunately this knowledge was used to further promote the herbicide, rather than recognize its dangers to the environment, public health and food safety.

<u>Glyphosate Soil Microbiological Effects</u> -

Glyphosate is a non-selective, broad spectrum herbicide. It kills plants by disruption/inhibition the EPSPS enzyme (the shikimic pathway) which is plant essential for synthesis of aromatic amino acids. It also stimulates infection of roots of susceptible plants by certain soil micro-organisms, allowed by a decrease in normal plant biochemical defense compounds called phytoalexins. Kremer et al (5) observed that glyphosate treated soybeans, both HR and non-HR cultivars, exuded to soils higher levels of carbohydrates and amino acids, which in turn stimulated soil fungal populations. Kremer and Means (6) also report that glyphosate interactions with rhizosphere microorganisms occurred with maize (corn) crops, stimulating pathogenic *Fusarium*, and altering other soil bacteria colonization. They note that root colonization by the pathogenic *Fusarium* increased significantly after glyphosate applications during the growing seasons, with heavier infestation on HR resistant cultivars of both soybeans and corn, compared to non-HR cultivars and crops not treated with glyphosate. Other observed negative effects were reduced manganese plant translocation and availability, antagonistic bacterial effects, and reduced soy nodulation, and consequent reduced nitrogen fixation. This nodulation nitrogen fixation effect is counterproductive to a key objective to crop rotations with legumes (such as soybean) which can help build the nitrogen content in soils, and consequently reduce the demand for nitrogen fertilizer additions. Similar concerns may also apply to the recently approved HR GE alfalfa, the leading forage and legume crop.

Recently published related research by Johal and Huber (7) has documented an increased incidence of damaging fungal infections in croplands treated with glyphosate. They state, " this relatively simple, broad spectrum, systemic herbicide can have extensive unintended effects on nutrient efficiency and disease severity, thereby threatening its agricultural sustainability." They note that glyphosate can induce weakening of plant defenses and resulted in increased pathogen populations with greater virulence of diseases. The micronutrient connection is due to glyphosate induced immobilization of key nutrients necessary for disease resistance in plants. In a related study by Fernandez et al (8) prior applications of glyphosate (within previous 18 months) have been statistically associated with wheat and barley cereal crop diseases in the following crop caused by Fusarium spp., in particular, head blight due to *F. avenaceum* and *F. graminearum*. Counter to the understood benefits of reduced tillage, no or minimum till methods also positively influenced enhanced disease intensity when in combination with prior glyphosate use. A concern with these serious fungal diseases is crop losses and downgrading or disqualification of grain quality due to the presence of mycotoxin compounds exuded by Fusarium which are toxic to cattle and people and for uses of barley such as malting. The economic consequences can be severe. It is thought that the soil health effect of glyphosate is disruption of the fungal communities and competitive natural balances, favoring the pathogenic fungi over beneficials. This study indirectly speaks to the longevity of activity of glyphosate and possibly its metabolic decay products in soils, negatively affecting crops in subsequent years.

Another mechanism of unintended harm from glyphosate is killing or functionally degrading beneficial non-target soil organisms, such as the important symbiotic nitrogen fixing bacteria, *Rhizobium japonicum*, in both HR and non HR soybean. Moorman et al (9) investigated the accumulation of hydrobenzoic acid in glyphosate treated cultures of Bradyrhizobium japonicum and found it to be increased by glyphosate cases, a negative indicator. Potential effects of glyphosate may be alteration of the symbiotic interactions between this bacterium and the herbicide.

Similar inhibitory negative effects may occur with nitrogen fixing symbiotic bacteria in glyphosate treated alfalfa and other host symbioses plants of these beneficial bacteria, and potentially non-symbiotic soil algae nitrogen fixers; more research is needed to evaluate these concerns.

While glyphosate is designed specifically to function with GMO crops, it has been found that a glyphosate metabolic and toxic decay product, aminomethylphosponic acid (AMPA) can negatively affect HR GMO plants. Reddy et al (10) determined that AMPA resulted in injury to HR soybean and reduced chlorophyll content, diminished shoot fresh weight, suggesting this is the damaging chemical agent.

Tesfamariam et al (11) investigated the effect of waiting time between glyphosate applications directly to soils versus foliar weed applications. They measured the phytotoxic effects on the non-target plant, sunflower at various time intervals after glyphosate applications. Detrimental effects were more pronounced in the case of foliar weed applications, indicating greater toxicity when glyphosate (or its metabolic decay products) translocated via weed root tissue residues compared to direct soil application.

Recent research by Bott and others (15) has discovered that glyphosate can be remobilized in the soil by subsequent applications of phosphorus fertilizers. This counters the claims that glyphosate has a short toxic persistence in soils. It has long been known that glyphosate competes with other forms of applied phosphorus for binding sites, notably on soil clay particles. The Bott et al study examined soybean as a test crop, with numerous different soil types, and multiple glyphosate and phosphorus application rates. It revealed that the remobilization of the herbicide glyphosate by P-fertilization does occur and can damage subsequent plantings. On glyphosate treated soils, significant soy plant damage was observed, including shikimate accumulation in root tissue (an indicator of glyphosate toxicity), declines in germination, biomass, and plant nutritional status, etc. Soil type did have an effect on the nature and extent of plant effects, likely related to P fixation potential, CEC, plant available iron, textural properties and soil organic matter.

Reddy and Zablotowicz (69) studied the effects of various formulations of glyphosate on HR-GE soybean yields and observed injury such as reduced nitrogen fixing nodule biomass after late postemergence applications. With additional glyphosate applications the soybean plants recovered, which may be contributing to the need for greater rates and applications of glyphosate to avoid this otherwise negative effect on yield.

Glyphosate and AMPA Environmental Dispersal and Contamination –

Glyphosate and metabolites such as AMPA are increasingly being found in the general environment, including natural waterways, the littoral plant communities, benthic organisms and mucks, and even in the atmosphere. This is a disturbing but not unexpected finding since glyphosate has been used for more than 3 decades and in the recent two decades it has become the number one herbicide throughout the world. It was once considered and represented as a non-persistent pesticide and relatively benign. That is now clearly challenged by mounting evidence not only about its presence in the general environment but by new research into the toxicity to many organisms other than the target weeds.

Kolpin et al (20) reports on glyposate and AMPA occurrences in surface water streams, including one Colorado location, the South Platte near Denver. This study focused on sampling of municipal wastewater treatment plant effluents, and upstream-downstream of the receiving streams. Overall, there was a two fold increase in detection of glyphosate and AMPA, comparing upstream from downstream; and AMPA was detected 67.5% compared to glyphosate (17.5%). While this indicates urban uses of this herbicide are significant contributor to dispersal, it also shows that the degradate AMPA is very important to track in environmental evaluations, not just the parent compound glyphosate.

In another study Kolpin et al (19) reported on herbicides and degradates in municipal wells in Iowa. They found a 53% frequency of occurrence of herbicides and associated degrades in these drinking water supplies during a 2001 sampling. In this work, glyphosate and AMPA was not detected.

Very little is known about atmospheric occurrence or transport and depositional fate of glyphosate and AMPA. However, very recent work by the USGS and University of Minnesota has been published by Chang et al (21). They sampled air particulates in Mississippi and Iowa and rain in Indiana during growing seasons. Glyphosate was detected 60 to 100% of the time in both air and rain. Glyphosate concentrations were higher in rain than other high use herbicides. For the Iowa case, they estimate that approximately 0.2% to 0.7% of glyphosate that is applied was measured in air samples and ultimately washed out of the atmosphere in wet deposition at remote locations from the point of crop use. Given the huge amounts applied this is a quite significantly large drift of volatiles that release to the general environment. This can have profound impact on non-target plants, and on organic production, and non-target animals. For example, in Mississippi alone, during 2008 and estimated 2,750 kg of glyphosate was applied to crops with a combination of aircraft and ground rigs. AMPA was detected at approximately 5 to 10% of the concentrations of glyphosate, lower during the major application seasons and increasing with time after last application. Rain is believed to be an efficient removal mechanism for these airborne toxins, since they exist as particulates, removing on average 97% of the atmospheric load by a weekly rainfall of $\geq$30 mm (about 1.1"). The question remains of course about the toxic effects on non-target plants where this deposition ends up. The two mechanisms for suspension of glyphosate and AMPA in air are immediate drift from sprayer application and post application wind erosion of particulate glyphosate and AMPA from the surface of soils.

In a dryer climate such as Boulder county, deposition mechanisms of these glyphosate and AMPA herbicide particulates will be different than the Mississippi valley. Nevertheless application drift and consequent chemical trespass is always a significant concern with any spray applied agricultural chemical. But subsequent wind erosion and offsite deposition of the soil particles containing such herbicides as glyphosate and its degradate AMPA is also quite important and likely an important local contamination mechanism to neighboring farms and general environment, given the windy character of cropland in Boulder county.

Littoral and periphyton freshwater community ecological effects of glyphosate have been observed. Vera et al (22) studied the effects of glyphosate on macrophyte colonization in outdoor experimental aquatic mesocosms. They simulated glyphosate runoff and aerial drift contamination of constructed shallow pond environments. They observed an algal eutrophication stimulation by Roundup, likely due to excess available phosphorus, which in turn produced a delay in the periphytic colonization of vascular wetland plants. Cyanobacter species were also favored by mesocosms receiving input of glyphosate.

A comprehensive literature survey has not been conducted in this area of glyphosate and AMPA ecological and non-target species effects. The above discussion is considered very incomplete at this time.

Glyphosate has deleterious effects on non-target species, some of which are threatened or endangered. Loss of habitat by excessive use of agricultural herbicides on field margins and conservation areas has been identified as a significant contributing factor to populations declines of many beneficial insects, including pollinators, and species that depend upon insects, such as amphibians and insectivorous birds.

The U.S. Fish and Wildlife Service, as a settlement of a lawsuit, has just agreed to begin assessing the effects of widespread use of herbicides, including glyphosate, on the bidoversity losses and T& E species, and to provide that input to the EPA pesticide risk assessment for pesticide registrations and re-registration actions (61). Glyphosate is currently in the reregistration review process by EPA, a decision delayed numerous times, in part due to such gaps in knowledge about environmental effects such as habitat destruction and T&E species, plus the human health effects.

There have been recent scientific studies that have shown the deleterious effects on honey bees from exposures to glyphosate (59)(60). Sol Balbuena et al (59) found that glyphosate exposures at sublethal levels caused honeybee navigational disturbances in homeward flight abilities due to impaired cognitive capacities, with negative consequences for colony foraging success. Herbert et al (60) found that honeybees exposed to glyphosate demonstrated reduced elemental learning and memory retention as related to reduced olfactory nectar reward sensitivity and associative learning, causing the potential for preferential collection of glyphosate contaminated nectar being foraged and returned to feed the hive. Somewhat similar effects have been observed with honeybees exposed to sublethal amounts of neonicitionoids.

Mecurio et al (70) determined the persistence of glyphosate and AMPA in seawater and found that half-lives ranged from 47 days to 315 days, depending upon water temperature and light conditions. Darkness extended the persistence, and the sorptive characteristics of glyphosate to soils, and its water solubility all contribute to the widespread contamination by this herbicide in all types of waters. Its longer persistence in dark would also indicate its potential for long times before degradation in ground waters.

Preliminary (unpublished) surface water data from the Colorado Department of Agriculture (analysis by CDA) and Colorado Department of Public Health and Environment (sampling by CDPHE) document occurrences of glyphosate in surface waters in the South Platte River system (64); see table below. Unfortunately sampling by CDA/CDPHE has not been conducted in the Boulder Creek and St Vrain tributaries, only mainstream rivers.

Surface Water Quality Sampling, Colorado Department of Public Health and Environment

South Platte Sampling Stations, June 2013, Glyphosate Results

SAMPLE NO	WQCD SITE	SITE DESCRIPTION	Active Ingredient	RESULT ug/L
001	5145	SOUTH PLATTE RIVER UPSTREAM OF BIG DRY CR	Glyphosate	0.86
002	5140	SOUTH PLATTE RIVER @ FT. LUPTON	Glyphosate	0.77
003	5138	SOUTH PLATTE RIVER AT WELD CR 18	Glyphosate	0.6
004	5137	SOUTH PLATTE RIVER AT WELD CR 28	Glyphosate	0.61
005	000130	SOUTH PLATTE RIVER NEAR PLATTEVILLE	Glyphosate	0.65

Soil and water sampling of pesticides on and near leased open space croplands, including glyphosate, has reportedly been conducted by Boulder County Parks and Open Space but that data has not been publicly released yet despite public requests for the data (67).

Overall, studies have observed glyphosate to be in all compartments of the terrestrial, aquatic, air, soil environment. It is simply widely dispersed and likely will increase as long as its use in agriculture and urban uses continues. A particular concern that would stimulate even greater occurrences is the anticipated introduction of glyphosate resistant urban lawn and golf course grasses. If that happens, the prospects for human contamination will escalate greatly.

Glyphosate Effects on Non-target Animal Species

Numerous scientific papers have reported on the ecological effects of glyphosate and glyphosate containing herbicides. Following is a review of a sampling of such recent papers.

Amphibians are of concern in ecosystems, and are particularly vulnerable to environmental poisons which they can absorb through their skins, as well as in foods and water ingestion. Yadav et al (83) studied the effects of Roundup on tadpoles of the Indian skittering frog under varying stress conditions. They determined short term (96 hr) and 10 day LC50 values of about 3.4 to 3.8 mg/L, and 1.9 to 2.1 mg/L, respectively, which they considered environmentally relevant concentrations. They also observed development of micronuclei in erythrocytes of the tadpoles, indicating genotoxic effects at 1 to 3 mg/L. Another frog study in Columbia by Meza-Joya (85) studied the toxic, cytotoxic and genotoxic effects of Roundup SL-Cosmoflux 411 F formulation, the product used to defoliate coca crops. Equivalent exposures to aerial application rates of 5.4 ug/cm2 and concentrations above 95 ug/mL showed clear cytotoxicity and induced DNA breaks. There are numerous other studies involving amphibians indicating similar concerns with toxicity to glyphosate, Lushchak et al (87), Wagner et al (88), Moore et al (89), Fuentes et al (90), Relyea (91), Howe et al (92).

Piola et al (84) examined earthworms (Eisenia andrei) for toxicity with commercial formulation Roundup and another more concentrated glyphosate containing product Mon 8750, thought to be a commercial technical grade without adjuvants. The Roundup was 4.5 times more toxic of the two, which authors ascribed to the presence of "inerts" with Roundup.

Highly of interest is a study by Shehata et al (86) from Germany of the effects of glyphosate on the microbiota of chickens, distinguishing pathogenic and beneficial microbiota. The results were that highly pathogenic bacteria Salmonella (entritidis. Gallinarum, and Typhimurium), and Clostridium (perfringens and botulinum) are all highly resistant to glyphosate. However most of the beneficial bacteria were moderate to highly susceptible to lethal effects of glyphosate. Campylobacter spp. was also susceptible to glyphosate. This finding indicates that glyphosate contaminants in feed to chickens could disturb the normal and essential gut bacterial community, and simultaneously increase the risk of harmful bacteria in the human foods from chickens.

Glyphosate Human Health Effects & Evidence from Other Mammalian Species -

Perhaps even more alarming is a growing body of evidence that glyphosate and its metabolic breakdown products are more toxic and longer lasting in the environment than previously reported or claimed by manufacturers, and toxic to non-target species, including humans. Glyphosate has been preliminarily implicated in epidemiological studies as a causative agent of neural defects and cranial-facial birth defects in populations in Chaco Province of Argentina (12). Those studies are considered by many as insufficiently controlled studies or peer reviewed. However they should be considered seriously and should justify additional research. More thorough and controlled medical science from University of Buenos Aires, Argentina, by Paganelli et al (13) investigated health effects of glyphosate herbicides with embryonic tadpoles and found teratogenic effects, related to impairment of retinoic acid signaling. Retinoic acid biochemistry is associated with the observed human birth defects and cranial-facial malformations noted in the above mentioned Chaco Province epidemiological reports.

Gasnier et al (16) examined the effects of glyphosate and various formulations on human liver HepC2 cells, a well known model for xenobiotic toxicity. They measured cytotoxicity, genotoxicity, anti-estrogenic and anti-androgenic effects, as well as androgen-estrogen conversion and mRNA. All measured parameters were disrupted within 24 hours at sub-agricultural doses with all of the glyphosate formulations. The nature of formulations had significant effect, indicating possible synergistic effects from multiple ingredients. They conclude, "Glyphosate-based herbicides present DNA damages and CMR [*carcinogenic-mutagenic-reprotyoxic*] effects on human cells and in vivo." And further, "These herbicides mixtures also present ED [*endocrine disruption*] effects on human cells, at doses far below agricultural dilutions and toxic levels on mitochrondrial activities and membrane integrity." They also note that the nature of the glyphosate formulation, that is the various other chemicals used in combination with glyphosate, have a significant effect on observed toxic effects. Also of note is that the effects were observed at levels near the residual authorized levels in transgenic feed stuff. Clearly they raise human and animal health warnings that have not previously been noted.

A major treatise on the birth defects in human and animal from Roundup/glyphosate was recently completed by Michael Antoniou et al (23), just published in June 2011. Antoniou is head of Gene Expression and Therapy Group, Dept of Medical and Molecular Genetics, King's College London School of Medicine UK. The major thrust of this report is the link of glyphosate to birth defects. The report also reviews independent scientific literature linking glyphosate to endocrine disruption, damage to DNA, reproductive and developmental toxicity, neurotoxicity and cancers. That study has since been substantially updated in 2014 by Fagan, Antoniou and Robinson (330 pages)(63), with a broader scope investigating the safety and efficacy of genetically modified crops and foods.

Dallegrave et al (24) published in Reproductive Toxicology research on assessing reproductive effects of glyphosate exposures of pregnant female Wistar rats on the offspring. The results showed, "glyphosate-Roundup did not induce maternal toxicity but induced adverse reproductive effects on male offspring rats: a decrease in sperm number…and daily sperm production during adulthood, an increase in the percentage of abnormal sperms and dose-related decrease in the serum testosterone level at puberty, and signs of individual spermatid degeneration during both periods…..and vaginal canal-opening delay in exposed female offspring."

Romano et al (25) also studied Wistar rats, and found related effects. They state, "results showed that the herbicide [glyphosate] significantly changed the progression of puberty in dose-dependent manner; reduce d the testosterone production in semineferous tubules morphology, decreased significantly the epithelium height." They conclude, "commercial formulation of glyphosate is a potent endocrine disruptor in vivo, causing disturbances in the reproductive development of rats when the exposure was performed during the puberty period."

Manas et al (26)(27) conducted research using Comet assay and cytogenetic tests to investigate genotoxic effects of both glyphosate and AMPA. Glyphosate was found to be genotoxic in the comet assay with Hep-2 cells of mice. With AMPA there was a significant level of DNA damage or genotoxicity in Hep-2 cells; in human lymphocytes there was statistically significant clastogenic effect; and in vivo micronucleus tests showed significant increases in toxicity as well. AMPA was found to be genotoxic in three different tests performed.

Bolognesi and colleagues (28) tested genotoxicity of glyphosate and Roundup formulation with mice, treated intraperitoneally, using a battery of tests; and also using human lymphocyte cells, in vitro. Both pesticide forms. DNA damaging activity was observed as DNA strand breaks, chromosomal alterations, indicating genotoxicity.

Benachour and Seralini (29) evaluated toxicity of four different formulations of glyphosate and adjuvants (POEA) on three different human cell types (placental, umbilical cord vein, embryonic kidney) using low dilutions, well below agricultural levels, to simulate possible low residue levels found foods or feed. All Roundup formulations caused cell death within 24 hours, inhibiting mitochrondrial activity, necrosis, and induction of apoptosis. Effects were confirmed by observed DNA fragmentation, and nuclear fragmentation and shrinkage. It was found that AMPA and POEA separately and synergistically damage cell membranes. The mixtures of these formulation ingredients are generally more harmful when combined with glyphosate, confirming the labeled "inerts" are not inert. Benachour et al (30) provide additional research defining the time and dose dependent effects of Roundup on human embryonic and placental cells.

Epidemiological studies conducted in Sweden by Ericksson et al (31) has confirmed an association between known exposure to phenoxyacetic acids and non-Hodgkins lymphoma (NHL), and have further strengthened an association between exposure to glyphosate and NHL. The latency period typical for glyphosate and onset of NHL is often greater than 10 years. Work by Anneclaire De Roos and colleagues (32) examined the cancer incidence among 57, 311 licensed glyphosate exposed pesticide applicators in Iowa and North Carolina. There was a suggested association between exposure and multiple myeloma incidence, but not other cancer subtypes; further analysis for longer term assessment is planned.

The effects of glyphosate on human placental cells, and aromatase, the enzyme responsible for estrogen synthesis was researched by Richard and colleagues (33). Glyphosate and Roundup were found to be toxic to human placental JEG3 cells within 18 hours at concentrations lower with agricultural use. Roundup with adjuvants was more toxic than glyphosate alone. At lower concentrations both forms were disruptive to aromatase activity and mRNA. Endocrine disruption was observed, and is suggested similar effects may be found in other mammals.

Aris and Leblanc (35) tested for blood levels of glyphosate, AMPA, glufosinate and its metabolite MPPA, plus the Cry1Ab protein (a Bt toxin) in the blood of non-pregnant, pregnant and their fetuses, performed in Quebec, Canada . Glyphosate and glufosinate were detected in non-pregnant women.

MPPA and CryAb1 toxin was detected in both non-pregnant and pregnant women as well as their fetuses. This opens questions about the effects and exposures of these pesticides on human embryos, and raises questions about transfer of these toxins across placenta. In an epidemiological study in Ontario of farm populations, an association between preconception exposure to glyphosate and elevated risk of late term abortions was observed (36).

Anadon et al (34) reports in rat brain tissue glyphosate induced 5-hydroxytryptamine (5_HT), serotonin and dopamine depletion, in dose-dependent effects in frontal cortex, midbrain and striatum, with accompanying increases in the metabolites of serotonin and dopamine.

In Sri Lanka a pesticide control study arose during the civil war, wherein glyphosate and other agricultural chemicals were banned in rebel held portions of the country. In studies by Jayasumana et al (72) of the incidence of an epidemic of chronic kidney disease which arose in the government controlled areas of rice production but not in the rebel areas, a hypothesis of cause and effect of field workers exposure to glyphosate was made. This was subsequently investigated and explained by the unique metal chelating properties of glyphosate that concentrated arsenic from hard waters of the area and destroyed the renal tissues of thousands of farmers, resulting in over 400,000 patients with kidney disease and an estimate death toll of 20,000. As a result of this, the government of Sri Lanka banned the use of glyphosate. A similar incidence of chronic kidney disease occurred in El Salvador and that country has also banned glyphosate.

Kurenbach et al (71) tested the effects of commercial formulations of glyphosate (and 2,4-D and dicamba) on microbes, in particular Escherichia coli (E. coli) and Salmonella enteric serovar Typhimurium. A key finding was that glyphosate induced a changed response to antibiotics, up to 6 –fold at concentrations within legal application levels. In particular, glyphosate increased the tolerance of E. coli to the antibiotic kanamycin. The importance of this finding is that glyphosate intake and presence in the human body can induce a possible antibiotic medicine resistance to potential pathogens. And moreover, the effects of multiple herbicides can have additive effectives on such antibiotic resistance effects. This could drive greater use of antibiotics to overcome the resistance, in both domestic animal rearing operations as well as clinical medical facilities and other uses of antibiotics for disease prevention. For humans, there is a growing crisis of the evolution of human pathogens that are resistant to antibiotics, the U.S. Center for Disease Control and Prevention estimates that more than 2 million people are sickened every year in the U.S. with antibiotic resistant infections, with at least 23,000 dying. To continue to use environmental contaminants such as glyphosate and other pesticides that stimulate such pathogen resistance is indeed unwise.

Research in Thailand, Thongprakaisang et al 2013 (95), demonstrated that glyphosate induces human breast cancer cell growth via estrogen receptors. Glyphosate induced the activation of estrogen response element transcription activity 5 to 13 fold over controls. These results indicated that low and environmentally relevant concentrations of glyphosate possessed estrogenic activity. They also noted that there is an additive estrogenic effect between glyphosate and genistein, a naturally occurring phytoestrogen in soybeans.

A large number of laboratory toxicology studies have been conducted in recent years with glyphosate in its various formulations, many involving rats in long term studies, some with human cells, and have indicated positively that glyphosate is a cancer causing chemical, as well as causing reproductive dysfunctions, neurotoxic effects, and many other diseases.

Mesnage et al (94) conducted a meaningful study with rats for an extended 2 year period administering 0.1 ppb Roundup (50 ng glyphosate equivalent/L) via drinking water. The study observed a marked increase incidence of anatomorphological and blood/urine biochemical changes indicative of liver and kidney structure and functional pathology. The results suggest that chronic exposure to a glyphosate based herbicide at ultra-low environmental dose can result in liver and kidney damage with potential significant health implications for animals and humans.

In another rat study, Romano et al (93), glyphosate was shown to alter aromatase activity and decrease serum testosterone concentrations, with expressions of early onset of puberty and other reproductive related abnormal effects such as hypersecretion of androgens, increased gonadal activity and sperm production.

The papers with laboratory rats and similar test mammals are so numerous in this area that this review paper cannot cover all of them. Refer to a few of the following papers for more detail: Cavalli et al (74), Seralini et al (75), Cattani et al (76), Peixoto (77), Astiz et al (78), Chaufan et al (79), and many others.

Glyphosate has recently been patented as an antibiotic itself. This points to other significant concerns about the effects of contamination of human foods and animal feeds. The linkage of glyphosate to numerous human health diseases and maladies involving the disruptive and toxic effects on otherwise healthy gut microbiome has been increasingly examined.

Beecham and Seneff (80) have postulated a link between autism spectrum disorder and glyphosate in a literature review paper of 2015. They postulate that glyphosate acting in utero on human fetuses disrupts neurodevelopment in a non-dose dependent manner. Their theory focuses on published data involving the interaction of harmful glycine mimetic related to calcium regulatory factors for certain neurons; the N-methyl D-aspartate receptor (NMDA), the glycine receptor (GlyR) and/or the glycine transporter protein 1 (GlyT1). The non-dose dependent aspect is based on more recent toxicology involving time sensitive exposures rather than simply concentration thresholds for effects. Another paper by Beecham and Seneff, just released Jan 2016 (82) reviews further the postulate link between autism and glyphosate formulated herbicides. They discuss the chelating properties of glyphosate and interference with manganese-dependent enzymes, notably the maternal pituitiary manganese dependent protein Phosphatase 1, which can affect thyroid stimulating hormone (TSH). Mid pregnancy maternal reduced TSH has been correlated with increased risk of autism in offspring.

Another paper, Seneff, Swanson and Li (81) develops other connections between gut dysbiosis and neurological diseases induced by glyphosate and aluminum on the pineal gland. This is related to glyphosates disruption of cytochrome P450 enzymes. All of these papers three papers rely on studies done by Swanson (41) that strongly correlate the increasing use of glyphosate with genertically engineered crops and the dramatic rising incidence in autism (and several other diseases and ailments in the U.S.) over the same time period from mid 1990s to the present.

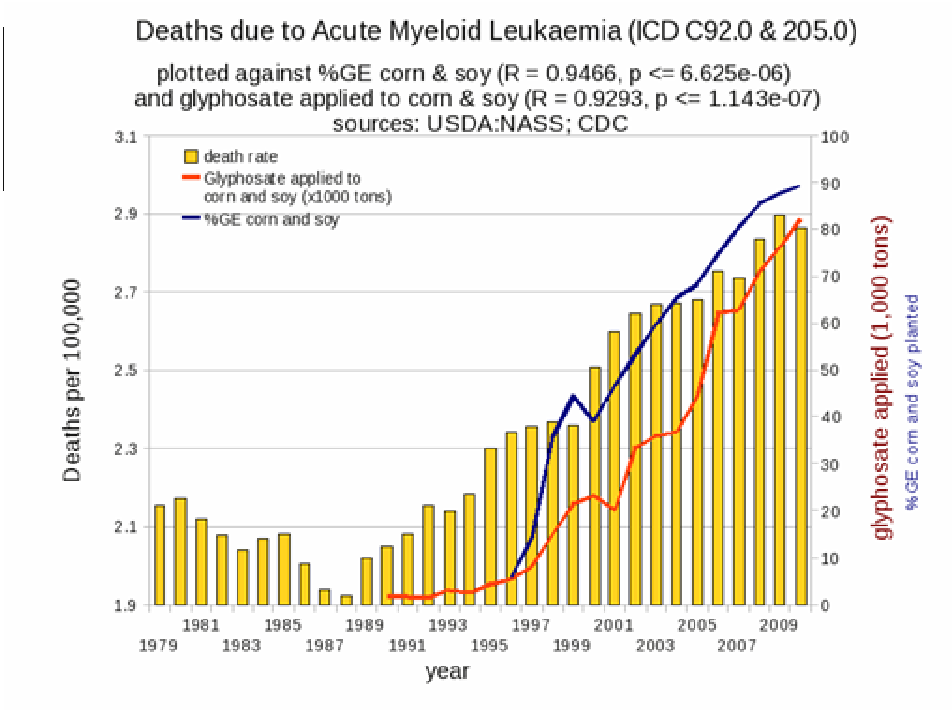
Nancy Swanson and others (41) collected U.S. government databases and time trends on GE crop production, agricultural glyphosate use from USDA, and disease incidence and epidemiological data for numerous diseases from the Center for Disease Control and Prevention (CDC). They performed statistical analyses of 22 diseases in time-series data sets. Highly significant Pearson correlation coefficients were found between the dramatic rise in the use of glyphosate and accelerating incidence of many of the diseases examined. The authors suggest that these correlations warrant serious examination of the potential that glyphosate may be causing serious health effects on the consumers of these crops grown with glyphosate herbicide residuals in the harvested crops and therefore in foods.

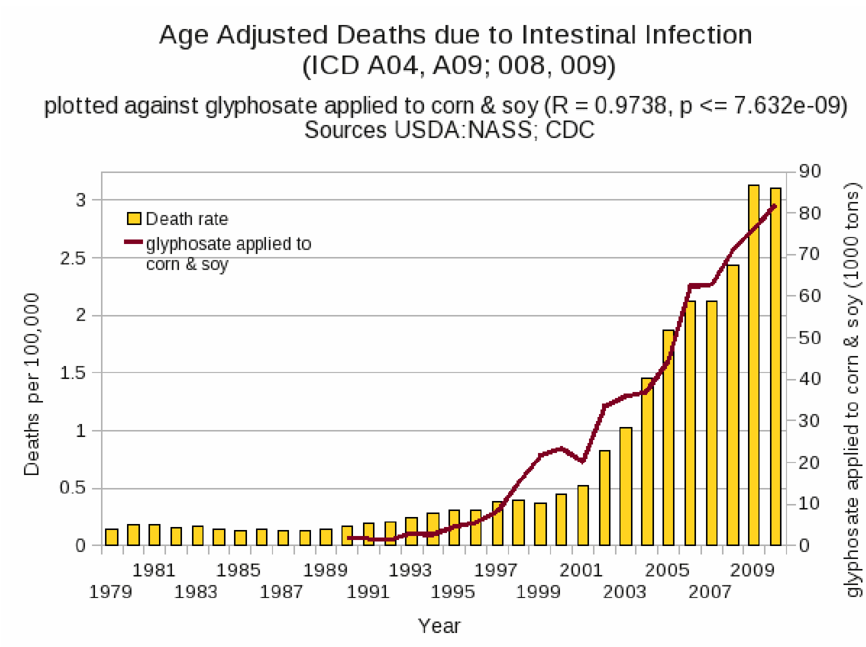
The co-authors, Anthony Samsel and Stephanie Seneff, teamed to conduct more in depth analysis of the linkages indicated by the Swanson et al (41) correlations between rising incidence of diseases coincident with the rising of use of glyphosate. They have since authored four peer reviewed papers in various journals:

I. Glyphosate Suppression of cytochrome P450 enzymes and amino acid biosynthesis by the gut microbiome: pathways to modern diseases, 2013 Entropy 15, 1416-1463
II. Glyphosate, pathways to modern diseases II: Celiac sprue and gluten intolerance, 2013 Toxicology 6(4), 159-184.
III. Glyphosate, pathways to modern diseases III: neurological diseases, and associated pathologies, 2015, Surgical Neurology International 6(45)
IV. Glyphosate, pathways to modern diseases IV: cancer and related pathologies, 2015 Journal of Biological Physics and Chemistry 15, 121-159.

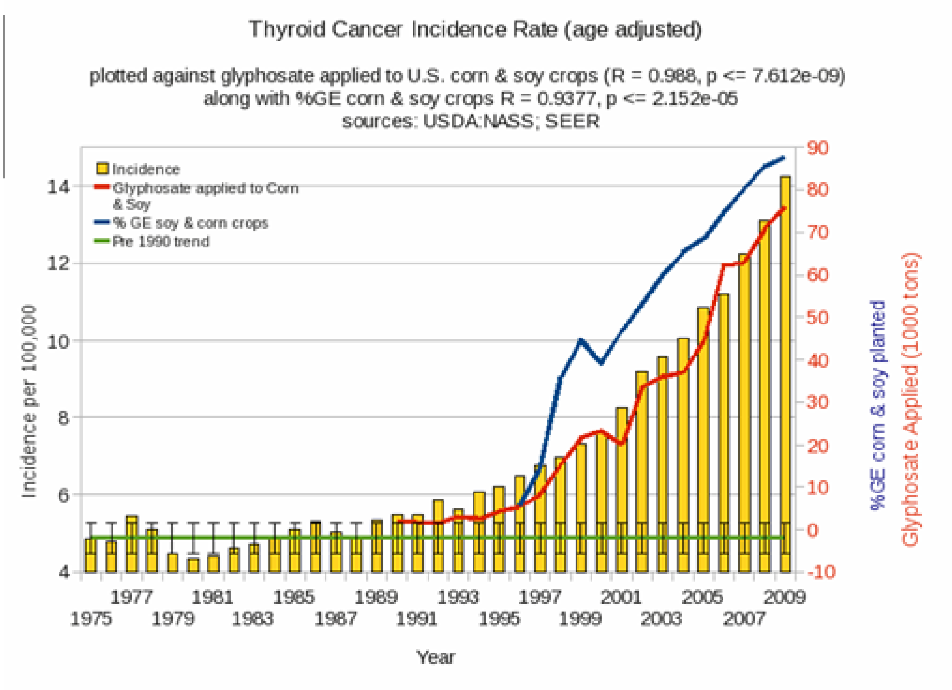
Included below are just four graphs illustrating the correlations reviewed in the Swanson et al (41) and the Samsel and Seneff papers (42)(43)(44)(45). Presented as examples of several diseases are time trends for the dramatic rise in acute myeloid leukaemia, deaths from intestinal infections, diabetes and thyroid cancer. Please take particularly note to the sudden jump from the pre-1990 trend lines in green for diabetes and thyroid cancers, and note that herbicide tolerant (Roundup Ready) GE crops were first introduced in 1995.

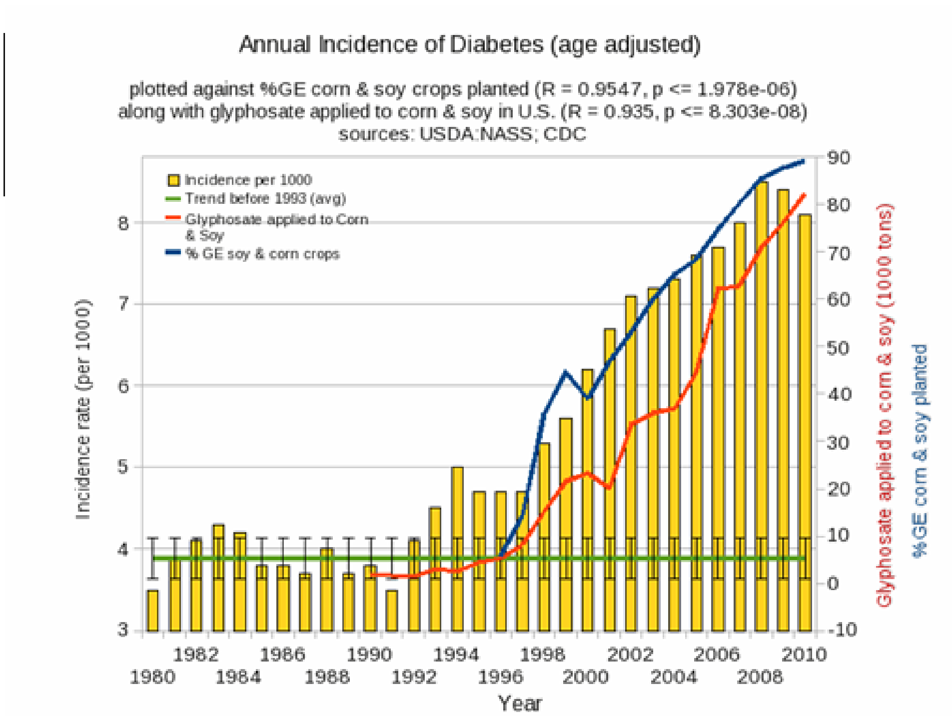
While these correlations and literature reviews are indicative of some troubling potential causative effects on the very serious rise in incidence of multiple human diseases since the early 1990s and glyphosate prevalence in the foods and environment, they of course are not absolute proof of causation. However, with all of the other scientific studies that have been reviewed above, there is serious concern with glyphosate and its damaging health effects on many animals including humans.





*Plot prepared by Nancy Swanson from available data online





Source of above four slides: Swanson et al 2014, Journal of Organic Systems 9(2)

It has also been very recently postulated that glyphosate may be a causative agent in the epidemic in Latin America of microcephaly birth defects, that health agencies and the press has been otherwise attributing to a mosquito vectored ZIKA virus. These specific birth defects, cranial malformations and microcephaly, were previously documented several years ago in rural agricultural village areas of Argentina coincident with heavy applications of glyphosate on soybean crops (12) and laboratory animal testing demonstrated similar cranial abnormalities with exposures to glyphosate (13). Further investigation is warranted of this possible pesticide linkage as well as the ZIKA virus hypothesis.

Endocrine disruption and cytotoxicity of glyphosate has been researched by Young, Ho, Glynn and Edwards in Australia (82). They determined that the Roundup formulation was more cytoxic in experiments with human placental JAr cells, than the technical ingredient glyphosate alone, and cytoxicity was observed at exposures comparable to Australian drinking water guidelines for glyphosate (0.0059mM). Gasnier et al (73) also determined that glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines.

Glyphosate - Human Exposures from Foods and Beverages –

The first truth that needs to come out is that the U.S. federal government agencies responsible for the safety and monitoring and enforcement of food safety have simply not been doing their jobs with regard to monitoring residual contamination from glyphosate and the metabolite AMPA. There are three U.S. federal agencies with the following roles:

- The U.S. Environmental Protection Agency (EPA) registers the use of pesticides and sets tolerances (maximum allowable amounts of residues in or on foods).
- The Food and Drug Administration (FDA) is charged with enforcing tolerances in imported foods and domestic foods shipped interstate.
- The U.S. Department of Agriculture, Food Safety and Inspection Services (FSIS) monitors and enforces tolerances for meat, poultry and certain egg products.

The FDA conducts a very limited sampling of selected foods such as vegetables, fruits, grains with the Pesticide Monitoring Program (PMP) and the Total Diet Study (TDS), however the FDA has not sampled and analyzed for either of these chemicals in foods.

The USDA-FSIS has also conducted a pesticide residue monitoring program, the Pesticide Data Program (PDP) since 1991, which includes selected raw agricultural products and some processed foods, usually actually performed by states and their labs, such as the Colorado Department of Agriculture (CDA).

The CDA does no known sampling and analysis for glyphosate in foods produced in Colorado, or sold within the state. The Colorado Department of Public Health and Environment defers to the CDA.

So here is the revelation:

None of these U.S. or Colorado agencies have monitored and analyzed for glyphosate or the metabolite aminomethylphosphonic acid (AMPA) in foods despite scores of other pesticides being monitored. This is despite the fact that glyphosate has been in use as an herbicide for more than 45 years, and is the largest herbicide volume use in the USA (and worldwide). One can only conclude either total government malfeasance and incompetence, or a willful decision compromised by outside influences to not even look for residuals and violations. The infamous Donald Rumsfeld slogan should be invoked: "The absence of evidence is not evidence of absence". The FDA and USDA and EPA must follow another recent slogan in the military, "Don't ask and don't tell", or a corollary "Don't look and you will not find".

As of last week (Feb 17, 2016), the FDA has finally announced that it will for the first time begin sampling for glyphosate in foods. The reasons for this belated decision are not clear, but may have been stimulated by the WHO-IARC declaration in March 2015 that glyphosate is a probable human carcinogen and public or congressional pressure. Also in October of 2014, the U.S. Government Accountability Office issued a scathing report on the failures of these agencies to perform their responsibilities to protect food safety (96) A major part of that report revealed the total failures by both FDA and USDA to monitor for glyphosate, as well as gross statistical inadequacies in sampling methods and numbers of samples across food types. There is no sign yet that the USDA is improving its food safety monitoring program.

The single exception known of any U.S. government agency sampling for glyphosate in foods was conducted by the USDA in a single episode in 2011 which found glyphosate in 90% of 300 soybean samples. That testing revealed glyphosate and AMPA residues of 1.9 to 2.3 ppm (mg/kg of grain), respectively. (98)

Sampling of glyphosate residues in soybeans from Argentina (100) and other countries indicate higher concentrations than reported by the previously discussed single USDA episode of sampling (101).

However, others such as food safety agencies in other countries, independent researchers and private labs have documented the presence of glyphosate in many foods, and in the human body and in domestic livestock. Some of that data is reviewed below.

Myers and thirteen other respected international medical and food safety experts (46) just issued a consensus statement in the professional journal Environmental Health (2016), after reviewing world literature and then issuing concerns over the use of glyphosate-based herbicides and risks with exposures. All of these experts and co-authors have no conflicts of interest. They in particular note the fact that glyphosate is widely present in the global soybean supply and that human exposures are rising. They also note that the regulatory determinations of allowable daily intakes (ADI) in both the USA and European Union are based on outdated science, among other findings. One of the authors is the founder of The Endocrine Disruption Exchange, headquartered in Paonia, Colorado, Theo Colborn (recently deceased). This report is a resounding rebuke of the performance of the agencies charged with protecting the public health from glyphosate damages.

In 1993, the National Academy of Sciences published a report, Pesticides in the Diets of Infants and Children. This report ultimately resulted in U.S. Congress passing the the 1996 U.S. Food Quality Protection Act (FQPA) which contains a mandate to assure a "reasonable certainty of no harm" for pregnant women, infants and children. However, twenty years later, the failures of the U.S. government agencies to meet this mandate are many and pervasive. The example of failure to even analyze glyphosate in foods, the most heavily used herbicide in the world is a prime example.

Sampling of foods for glyphosate and AMPA in the European Union is also deficient, but somewhat better than in the U.S. Independent institutions and various countries have conducted limited monitoring and analysis for glyphosate. The UK based Soil Association issued a presentation recently, glyphosate Scientific Briefing: Glyphosate in our Bread (97). The report notes that glyphosate spraying of cereal grain crops has risen by 400 5 in the last 20 years, involving just over 1 million hectares and approximately 800,000 kg of glyphosate. This compares to about 150,000 kg in 1996. Cereal crops are treated up to 3 times per season. The rise in the use of glyphosate is matched by a rise in the concentration of glyphosate in bread in the UK, and between 17% and 30% of bread samples contained glyphosate in the most recent years (2012-2014)and the average concentration in 2013-14 was 0.2 mg glyphosate per kg of bread. Some of this data was from the UK Food Standard Agency which found glyphosate in 27 of 109 bread samples in 2012 (99).

Other prior testing for glyphosate in the UK has found wholewheat breads to more commonly have glyphoste contamination. In separate testing of wheat bran residues up to 5.7 mg/kg were found in one case (106)(105), and in a German study glyphosate residues in barley were measured at concentrations up to 23 mg/kg (107). As a result of these findings the UK government issued an advisory notice to farmers (102); and leading bakeries in Denmark no longer accept glyphosate treated grains (108)(105).

A just released study from Germany that glyphosate has been found in all of 14 popular German beers at concentrations ranging from 0.46 ug/L up to 29.74 ug/L (ppb). The German Brewer's Association admitted that low residues of the probable human carcinogen glyphosate could not be prevented because "the herbicide is now found virtually everywhere after decades of use in agriculture."(104) Compare these concentrations to the EU standard in drinking water of 0.1 ug/L (ppb).(109)

With Boulder County being the birthplace for craft beer brewing and a haven for scores of craft brewers, their ingredients are also very likely to be suspect to be contaminated with glyphosate…and some barleys are grown right here for these craft brewers as well as the major mainline brewers of Coors and Anheuser-Busch.

Sampling by non-governmental groups in European countries found 44% of city dwellers across 18 countries had urine containing glyphosate (105) and 70% of individuals in the UK had glyphosate in urine. Sampling of women's breast milk in Germany also had glyphosate contamination. (as reported by UK Soil Assoc. (97)) In Canada glyphosate was detected in 55 of blood samples in women, up to 93.6ng/mL (ppb).(110) A study in Iowa of farm and non-farm families detected glyphosate in more than 80% of children's urine. (111)

While much of the above discussion of glyphosate residuals in grains relates to soybean, and soybean is not a crop often grown in Boulder County, the fact is that many grain crops such as Roundup

Ready corn and sugar beets, as well as other grains and crops such as wheat, barley, dry beans, sunflowers, potatoes, etc. can also be contaminated with glyphosate due to the practice of “green burndown” or “desiccation”, spraying of glyphosate on non-resistant crops just prior to harvest to accelerated crop drying for the convenience of the farmer’s harvesting schedule. These desiccant uses are particularly concerning since they are done within one to two weeks of harvest, thereby maximizing the potential for glyphosate residuals to remain in the harvested crops. Very little data is known on this in independent literature, but the practice is promoted by the chemical companies (102) and governments and university Cooperative Extension Service (103), and unfortunately approved by the EPA in glyphosate labels despite the contradiction of spraying the crop…in essence defining it as a pest to allow such a use.

In 2009, the European Union, European Food Safety Authority (EFSA) conducted 186,852 tests on cereal samples for pesticide residues. But in this multi-country effort on five countries tested for glyphosate, 462 samples of which 42 tested positive.

In a news item from Global Research (112), the children’s cereal, Kellogg’s Froot Loops was found to contain 0.12 mg/kg (ppm) of glyphosate.

Moms Across America and Sustainable Pulse conducted glyphosate testing in breast milk, urine and water samples from across America (113). The results of that investigation were that glyphosate was detected in 3 out of 10 samples of breast milk of American women, levels ranging from 76 ug/L to 166 uq/L which are 760 to 1600 times higher than the European drinking water Directive. In the U.S. the allowable drinking water standard for glyphosate is 700 ug/L (7000 times higher than the EU standard). Urine samples were found to be 10 times higher than a similar study in the EU conducted by Friends of the Earth Europe in 2013. Drinking water samples with detectable concentrations for glyphosate ranged from 0.085 to 0.33 ug/L, 70 % with detectable concentrations >0.05 ug/L. Urine samples with detectable concentrations ranged from8.1 to 18.8 ug/L; 12 of 40 samples had detectable amounts at LOQ 7.5 ug/L.

What is known is that crops on Boulder County Open Space have been sprayed with glyphosate for harvest burndown, including beans, sunflowers, and some grains. (67) Allowing this use is an affront to common sense, and demonstrates no concern for public health and safety.

Rubio , Guo and Kamp (114) surveyed glyphosate residues in honey, corn and soy products. Sixty-nine samples of honey, with a limit of quantification (LOQ) and analytical range were 15 to 800 ppb, 59% of the samples were above the lower LOQ, values ranging from 17 to 163 ppb. Organic honey tested positive for glyphosate for 45% of the samples, ranging between 26 and 93 ppb. Glyphosate was detected in 10 of 28 samples of soy sauces with a concentration range of 88 and 564 ppb; none of the organic soy sauces had detectable glyphosate. Glyphosate was not detected in soy milk, tofu, or corn syrup at the LOQ and range of 75 to 4000 ppb.

Kruger et al (115) examined glyphosate in urine and organs of dairy cows, German and Danish, organic and conventional; and in urine of hares, rabbits; and urine from humans with conventional and organic diets, and also healthy and chronically diseased individuals. Cows in GMO free area had significantly lower glyphosate concentration in urine compared to conventionally managed and fed cows. Glyphosate was higher in humans with conventional feeding compared to organic; and chronically ill persons had significantly higher glyphosate residues in urine compared to health persons.

What is not known regarding Boulder County open space croplands is how much glyphosate is contained in the crops grown in our county, and particularly on the Boulder county open space croplands. From all indications where limited sampling has been conducted in other parts of the world, one can expect that the grains, sugar beets and other crops are in fact contaminated with this herbicide, possibly accumulating and are being sold into food products and animal feed products. And more concerning is the health effects on these consumers.

<u>Glyphosate Effects on Comparative Nutritional Quality of Crops -</u>

Baranski and a large team of international scientists (62) conducted a massive meta-analysis comparing conventionally non-organic (chemical) grown crops to organic crops which of course are not allowed to use pesticides such as glyphosate. The meta-analysis published in 2014, was based upon 343 peer-reviewed publications across numerous countries and crops, and "indicate statistically significant and meaningful differences in composition between organic and non-organic crops/crop-based foods" in the favor of organic crops. The" concentration of antioxidants such as polyphenols were found to be substantially higher in organic crops." Such dietary beneficial antioxidants have been linked to a reduced risk of chronic diseases and neurodegenerative diseases and certain cancers. And, "the frequency of occurrences of pesticide residues was found to be four times higher in conventional crops, which also contained significantly higher concentrations of the toxic metal Cd.

As noted previously, the failures of the USDA and FDA to collect data on glyphosate and AMPA in foods is a major failure, and we have a poor to nonexistent data base on what effects glyphosate has on food quality.

One factor that not mentioned yet is the regulatory agencies' history of raising of Acceptable Daily Intake (ADI) value, or the Chronic Reference Dose (cRfD), as these values are labeled in the EU and the USA, respectively. These values are in turn used to establish tolerance values for glyphosate in individual foods or food groups. The manufacturers of glyphosate have repeatedly requested raising of the allowable tolerances and EPA most recently, partly due to the evolution of glyphosate resistance in weeds making application rates non-efficacious. Currently, the U.S. EPA cRfD is 1.75 mg of glyphosate per kilogram of body weight (mg/kg/day) which was recently raised. The current E.U. ADI value is 0.3 mg/kg/day, established in 2002. The German Federal Institute for Risk Assessment is currently considering raising their ADI value from 0.3 to 0.5 mg/kg/day. A team of independent scientists is seeking a much lower value, down to about 0.1 mg/kg/day. The U.S. EPA are in the midst of a re-registration review for glyphosate, begun in 2009 but still engaged and a decision has been delayed several times, due out sometime in 2016.

One key missing element in determining the safety and risks of glyphosate is hindered by the almost total lack of data about the actual concentrations of glyphosate in grains, fruits, vegetables, meats, dairy products, eggs, etc. and the consequent inability to determine the actual doses experienced by the human population. The failures of USDA and FDA to monitor and analyze for glyphosate has greatly hindered this greatly. EPA has no good data base for establishing glyphosate tolerance values for foods. Catch 22. But countering this data deficiency is the large amount of medical evidence that has been reviewed herein, and much more that exists, that evidence indicating that EPA must choose precaution due to the warnings of great damage from this herbicidal product. And similarly, in the absence of prudent and precautionary regulatory actions by the EPA, Boulder County must choose to ban glyphosate to protect the citizens of the county and all persons that are consuming the foods that are produced in this county.

Glyphosate and Toxicity Enhancing Effects of Adjuvant Chemicals –

The city manager of the City of Boulder, Colorado released in 2011 a memo directing city parks and maintenance staff to cease using Roundup, a commercial version of glyphosate. The ban was triggered by recent research about the elevated health risks and toxicity of glyphosate in combination with an adjuvant surfactant chemical polyethoxylatedtalloamine (POEA)(14). Surfactants are commonly used with active agent pesticides to decrease the surface tension of applied liquids and cause greater contact and penetration of the active poison with plant tissues.

This city of Boulder Roundup ban is in concert with an overall policy trend by the City of Boulder and in draft versions of the (then) latest update to the Boulder Valley Comprehensive Plan to minimize the use of all pesticides except those identified as “minimum risk” under EPA definitions (FIFRA Section 25(b)).

Incredulously, the U.S. EPA does not review the actual formulations of pesticides that are actually used when it reviews the environmental and toxicity effects of a pesticide for registration or re-registration, or for setting allowable tolerances of pesticide residuals on foods. Furthermore, the EPA also does not require the inert ingredients to be listed or quantified on the labels or even publicly divulged, calling that information business confidential or secret. Toxicity studies required of pesticide registrants in their applications are also not required to be conducted with the actual formulations as sold and used, only the technical grade active ingredients (abbreviated as “a.i.”). And most corporation supplied toxicity studies are also declared secret, not available for public or even peer scientific assessment. All of this is an affront to legitimate scientific method, and invalidates the entire EPA review process.

Almost all pesticide products contain these so called inert ingredients in actual formulations to enhance the toxicity of the active ingredient. They may be surfactants to break surface tension and increase absorption into the organism. They may be synergists that biochemically increase the toxicity of the active ingredient by such mechanisms as slowing the active ingredient degradation by biochemical or other processes. Other mechanisms may include blocking or opening active neurological signal transmitter or enzyme production or activity sites, either directly by the inert ingredient or for attack by the toxic a.i.; or many other such mechanisms.

There are many different "inerts" used with glyphosate and the formulations can vary from high concentrations of glyphosate relative to inerts (e.g. about 40%), to quite low formula ratios, about 1%. And even for the many products involving glyphosate, the types of adjuvants also vary greatly from use formula and tradename and manufacturer, and consequently the actual formula toxicity also varies broadly (50).

Comparative toxicities to non-target organisms, such as various amphibians and aquatic species, by various glyphosate formulations compared to pure glyphosate has been demonstrated in published studies, e.g. Brausch et al (51) and Relyea (52), Howe et al (53) and others. In these, the as applied glyphosate formulations and inerts proved to be more toxic than glyphosate alone, to frogs (53), daphnia magna (an aquatic invertebrate(51), and a range of aquatic community algae and animals (52). This literature review is not complete and abbreviated for this report.

In the case of glyphosate, polyethoxylated tallow amine, also called POEA or POE-15, is an "inert" ingredient in many commercial formulations, including formulations of Monsanto's widely used RoundUp. This particular chemical, a surfactant, has been proven to dramatically increase the toxicity of RoundUp. Mesnage, Bernay and Seralini (48) published a report on the toxic effects of the POE-glyphosate formulation, glyphosate alone, and POE alone on human hepatic , embryonic, and placental cells. They found that all formulations are more toxic than glyphosate alone, and interestingly POE-15 was the most toxic individual component, at levels of 1 to 3 ppm, inducing cell necrosis. They demonstrated that the government established human acceptable daily intake (ADI) value which are based on glyphosate alone tests is totally inaccurate. They state,

> "*Since pesticides are always used with adjuvants that could change their toxicity, the necessity to assess their whole formulations as mixtures becomes obvious.*"

A later additional report by Mesnage et al in 2014 (49) further amplifies on the above findings. This expansive study included three major herbicides (including glyphosate), three insecticides (ncluding some neonicitinoids) and three fungicides, comparing their active ingredients toxicities to actual formulations with the adjuvants. Three human cells lines were the tested for mitochondrial activities, membrane degradations, and caspases activities. Eight of the nine formulatins were up to one thousand times more toxic than their singular active ingredients. RoundUp formulation was among the most toxic of herbicides and insecticides tested. They note in conclusion regarding glyphosate and glyphosate formulations:

> "*It is commonly believed that Roundup is among the safest pesticides. This idea is spread by manufacturers, mostly in the reviews they promote, which are often cited in toxicological evaluations of glyphosate-based herbicides. However, **Roundup was found in this experiment to be 125 times more toxic than glyphosate**." (**bold** emphasis added) …*

"In conclusion, our results challenge the relevance of the ADI (acceptable daily intake), because it is calculated today from the toxicity of the AP (active principle or active ingredient) alone in vivo. An "adjuvant factor" of at least a reduction by 100 can be applied to the calculation of ADI…As an example, the present ADI for glyphosate is 0.3 ppm (parts per million); for glyphosate-based herbicides it would be 3 ppb (parts per billion) or less."

But unfortunately, the EPA has not yet acknowledged this fundamental scientific flaw in its pesticide risk assessment and toxicity protocols to be obvious. They continue to understate the toxicity of glyphosate and essentially all pesticides by this major flaw by only requiring testing the active ingredient, and not the actual product formulations sold and applied in the field and environment. And the allowable residuals in foods and in exposure models that are built upon these flawed assessments are likewise fundamentally invalid and are not protective of public health.

Toxicity Enhancing Effects of Mixtures of Pesticides –

A similar problem to the failures to properly assess toxicity of such pesticides as glyphoste due to inerts, is the fact that pesticide risks are studied in isolation and EPA and risk assessment and regulatory agencies in other countries do not consider the real world of mixtures of many different pesticides being applied into the environment. These mixtures can have major combination and even synergistic effects, much greater than the single chemical effects, sometimes additive but often greater than simple additive effects. It is a common practice to tank mix pesticides for a single application, or simply apply one after another to the same site at short intervals.

With the increasing weed resistance to glyphosate by "super weeds", largely brought on by its extreme and increasing use of glyphosate, chemical companies are recommending the use of other herbicides in combination with glyphosate based herbicides, including older chemicals such as 2,4-D. Dow Chemical has recently introduced such a combined product called Enlist Duo (2,4-D and Glyphosate), and with unknown adjuvants…and companion new GE corn and soybeans that is tolerant of both herbicides. This constantly ramping up of more and more pesticides is really a treadmill. Dow Chemical claimed in its EPA registration applications that these two herbicides together were not acting in synergistic fashion, but simultaneously in their patent filing claimed the opposite. EPA reversed its approval of the Enlist Duo due to this falsification of data by Dow Chemical.

Other research on combination pesticide effects has been documented with glyphosate-based herbicides and certain fungicides with other pesticides, and the enhanced effects on honeybees above additive effects of single chemicals (54)(55)(56)(57). Many more such examples can be cited. But the message is clear, the EPA toxicity review processes to determine acceptable pesticide uses, rates, tolerances is seriously scientifically invalid by this compartmentalism or reductionist approach to what they claim to be science.

Crop Production Economics: Costs vs. Benefits -

This topic of farm profitability will be more fully developed by Mary Mulry in her presentation of an agricultural economic paper comparing organic crop production to conventional commodity crops using genetic engineered seed.

Already presented to the Commissioners is information about the effects of conventional agriculture and its high intensity use of chemicals and the external costs not built into the true costs of business:

- Effects on climate disruption from fossil fuels used in manufacturing and transport of nitrogen fertilizers to the fields, plus enhanced methane emissions from concentrated animal feeding, nitrous oxide from soils, and other volatile greenhouse gases from the use of soil sterilants and pesticides.
- Extreme costs to public health and health care and loss of human capacity caused by the damages from use of pesticides and associated chemicals
- Costs to the environment from losses of the ecological services of pollinators, and essential support from a balanced biodiverse ecosystem.
- Costs from losses of clean air, clean water, healthy soils
- Costs from losses of cropland productivity due to sterilized soils and eroded soils
- The cost to human welfare from loss of the aesthetic pleasures of being surrounded by birds, frogs, fishes, insects, worms, mammals, and all living things.

These unaccounted for economic losses caused by chemical farming are real. They are truly unsustainable practices in every sense.

Local chemical intensive farmers say that their economic profitability is improved by the use of glyphosate as an effective herbicide. They even argue that glyphosate and the multitude of toxic chemicals they use is essential to their livelihoods. They spray early upon weed emergence and say they can make fewer or no additional cultivation passes per crop cycle. This clearly makes their farming more convenient, and may arguably reduce tractor fuel consumption and labor. However, for truly sustainable farming, this does not account for many external costs such as long term soil health, human health, stimulation of the evolution of glyphosate resistant weeds, and other negative consequences that must also be considered. But these factors are not considered in the farming accounting systems, but are only assessed indirectly and often with great lag times, appearing as long term productivity declines, loss of non-target species, health care bills, etc.

Spraying of glyphosate does cause chemical trespass, even when done with care and observance of atmospheric conditions, sometimes damaging, destroying or threatening the crops and livelihood of downwind and downstream organic farms. These costs are often left for neighbors or subsequent generations to deal with. On balance, the risks of applying glyphosate and adjuvant toxins for the sake of current season profitability or the simplicity gains in farming are insufficient justification for the real costs.

Damages to Organic Farms from Pesticide Drift or other offsite contamination -

In 2013, a major incidence of glyphosate drift chemical trespass occurred in Boulder County. An boom spraying occurred adjacent to an organic farm. The victim was a well known and respected organic vegetable farmer and organic seed producer. This family lost their crops due to major damages to the vegetable crops and inability to harvest and sell them as certified organic produce, and ultimately lost their farm as a result of this pesticide trespass. The case was settled but with too little compensation and too much delay to offset the real damages to this farm. Supporting scientific demonstrations of the impact of the glyphosate drift on organic vegetable crops were conducted by an agricultural expert witness, and supported by other organic farmer.( ) Little support was provided by the CDA investigators in this matter. Some of the details on this egregious case are not available due to out of court settlement agreements. But the case illustrates the problems of use of this dangerous herbicide in off-site contamination and damages.

There is a clear danger of glyphosate entering waters of streams, lakes and irrigation ditches, that can subsequently be applied to downstream farms, resulting in damages to crops.

So the weed control benefits sought by farmers from this broad spectrum herbicide may in fact be counterproductive with negative effects on beneficial soil organisms, to longer term impacts on soil health, increased crop disease prevalence, and even reductions in crop yields or losses by mycotoxins, and with growing human health concerns to those applying it and coming into contact with this poison by its widespread use. A more in depth evaluation of glyphosate and related herbicides such as glufosinate is needed to assist in cropland policy development by BCPOS.

Recap - Summary –

The primary regulatory agency for herbicides such as glyphosate is the U.S. Environmental Protection Agency which must approve the use of such toxic agricultural chemicals that are designed to control or kill weeds. Glyphosate was approved decades ago, in the mid 1970s. However, based upon recent research findings it deserves a serious re-examination and much more unbiased scientific research across numerous disciplines, from soil chemistry and soil microbiology, to crop diseases, to animal feed effects, to food safety and human health effects, and comparative studies between more benign methods of agricultural production and chemical pesticide methods, etc.

Recent investigations into EPA prior knowledge of the harmful human health effects of glyphosate have come to light by independent researchers/investigators under Freedom of Information Act. Thousands of pages of documents from EPA files reveal that knowledge of the carcinogenic and other effects of glyphosate have been known by both the manufacturing corporation and the EPA since at least the early 1980s.

This information is provided in this report as an illustration of the influences of the corporate manufacturers of glyphosate on the EPA, and the resulting EPA malfeasance in protecting the public health and the environment from pesticides. This case is but one example. In addition to malfeasance, the EPA testing protocols and risk review processes are fundamentally scientifically invalid and seriously out of date with current toxicological, ecological, and food safety science. Accompanying this document is a book titled *The Myths of Safe Pesticides*, which it is hoped Commissioners and county staff will seriously read to understand the gross inadequacies of the regulation of pesticides, including glyphosate.

Until convincing additional research can prove the safety and necessity of glyphosate over the near and long term, its use should be discontinued. Given the mass of medical and ecological evidence already existing, it is unlikely that safety can be proven. The role of Boulder County should be to disallow its use until legitimate and independent scientific verification of safety can be assured. Those assurances are currently not indicated by unbiased independent science.

It should be noted that this review only deals with the environmental and health effects of the herbicide glyphosate and does not cover the issues of companion herbicide resistant genetically modified crops designed to tolerant it. That is the subject of other policy recommendations, rationale statements, and literature reviews.

It should also be noted that this literature review is not to be considered comprehensive and the sheer volume of published literature on these subjects is enormous and rapidly growing.

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