

## GMOs and big agriculture in the US

1. Implications of corporate control of a large sector of agriculture
2. Patent law and biotechnology
3. Biodiversity
4. Food labeling issues
5. Effects on non-target organisms
5. Human health and GMOs
6. Persistence in the environment

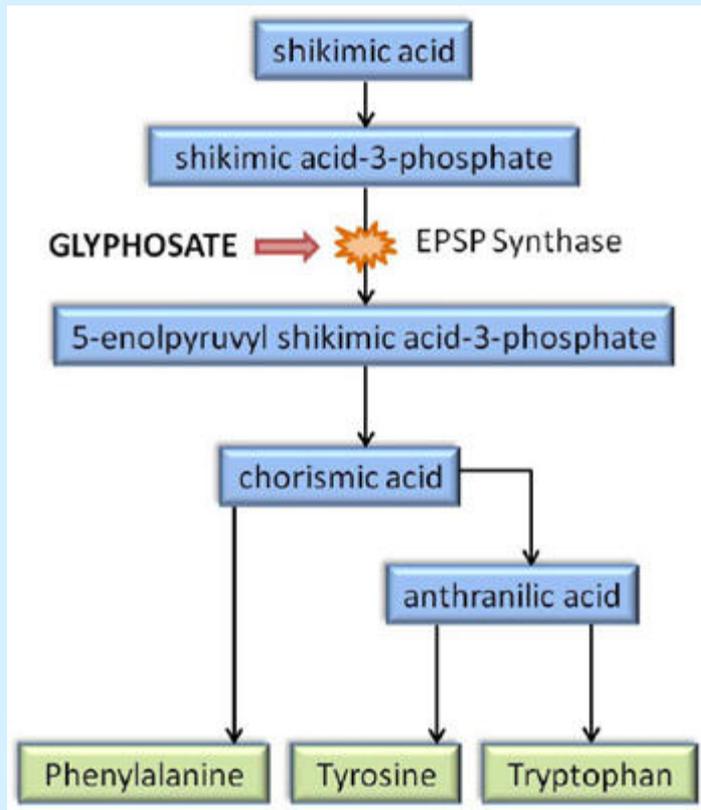
As scientists providing scholarly perspectives to the general public, we need to be aware that what we consider 'truth' is based on the best evidence available, but that is not always, or often not, the final story. DDT is an example. What was wrong with DDT, anyway? We all know it was bad, and it was banned. But why?

Rachel Carson was attacked vigorously by industry for her leadership!

Some issues with public perception:  
Conflate- combine several issues into one



The herbicide glyphosate (Roundup) blocks the shikimic acid pathway, preventing production of some of the 'essential' amino acids. They are essential because animals do not synthesize them. This means that the compound glyphosate affects a biochemical pathway not present in animals. Roundup kills all plants, and does not persist in the environment as much as many other herbicides.



For the most part, herbicides affect processes unique to plants, such as photosynthesis (Atrazine) or response to the plant hormone auxin (Weed B Gon or 2,4-D). However....dogs whose owners use 2,4-D on their lawns have an increased incidence of cancer (Journal of NCI).

# Herbicides: How Toxic Are They?<sup>1</sup>

Fred Fishel, Jason Ferrell, Greg MacDonald, and Brent Sellers<sup>2</sup>

Table 1. Comparison of oral LD<sub>50</sub> values for commonly used herbicides and consumer goods.

Herbicide	LD <sub>50</sub>	Common consumer chemicals	LD <sub>50</sub>
Paraquat (Gramoxone)	~100	Nicotine	9
Triclopyr	630	Caffeine	192
2,4-D	666	Bleach	192
Pendimethalin (Prowl)	1050	Tylenol	338
Atrazine	3090	Household ammonia (10%)	350
Glyphosate (Roundup)	4900	Codeine	427
Imazaquin (Image)	>5000	Table salt	3000

LD50 is the concentration of a chemical that is lethal for 50% of test subjects

Synthetic agrichemicals could be toxic, carcinogenic, or both. How is carcinogenicity determined? Not a simple issue. Non-Hodgkin's Lymphoma (one of the most common in US) rates in the US: 1 in ~50 will be diagnosed over a lifetime.

PRODUCT LIABILITY SPOTLIGHT

Roundup®

EXPOSURE TO ROUNDUP® MAY CAUSE  
**NON-HODGKIN'S  
LYMPHOMA.**

3/27/19: Jury awards \$80 to home owner who used Roundup. Monsanto was found to have hid internal studies showing carcinogenicity



**Public perceptions: Is this case about GMOs? NO. Is this case about toxicity of agrichemicals? NO. Is Roundup carcinogenic? MAYBE. Did Monsanto hide evidence from the public relevant to this case? YES. *Clinical Neurology News*: A groundskeeper developed Non-Hodgkin's Lymphoma after using Roundup sometimes spraying several hours a day. Allegation: Roundup's active ingredient, glyphosate, is a known carcinogen, and that Monsanto, its manufacturer, failed to provide appropriate warning regarding the dangers of product. Judge allowed into evidence internal emails and experts' warnings, as well as a 2015 WHO-IARC classification of glyphosate as "probably carcinogenic to humans".**



United Nations: World Health Organization's International Agency Research on Cancer (IARC) concluded that Roundup was 'probably carcinogenic to humans'.

International Agency  
Research on Cancer



World Health  
Organization

The US EPA  
concluded that  
Roundup was 'not  
likely to be  
carcinogenic'



The IARC has assessed nearly a thousand substances and activities, ranging from arsenic to sunbathing and hairdressing. IARC has determined that very few of compounds tested were “probably not” likely to cause cancer in humans.

Who is responsible for fact that 200 million acres of GMOs are grown in the US? Monsanto? Farmers? Consumers?

Are GMOs unhealthy/different from conventional food?

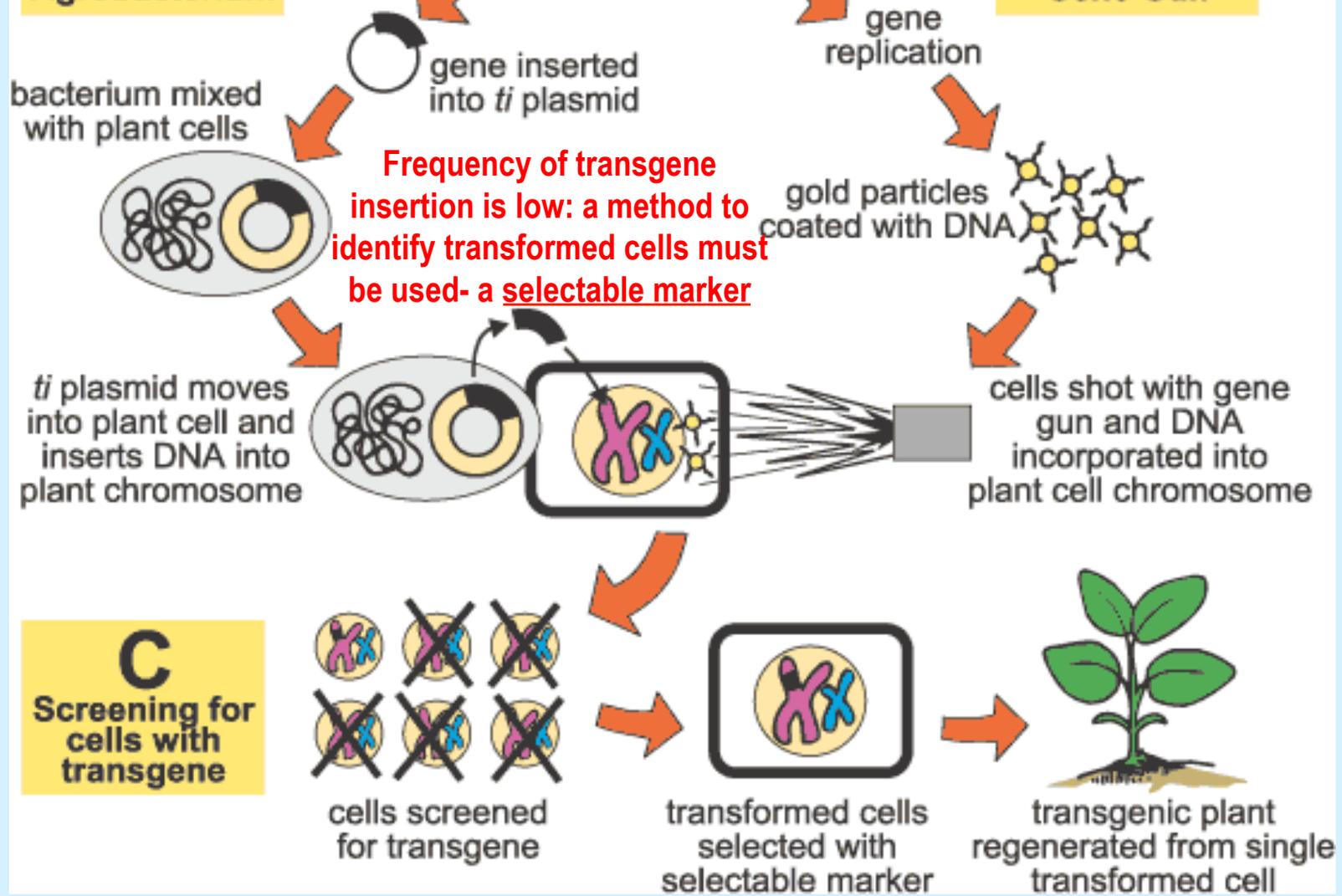


Do consumers have a right to know where they are spending their food dollars and to link this to their value system?

# GENE identified and isolated

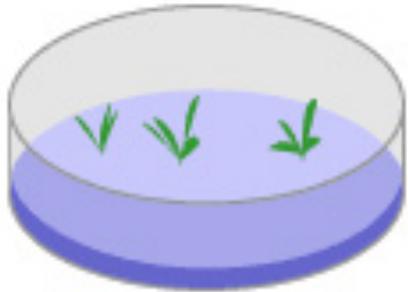
## A Agrobacterium

## B Gene Gun

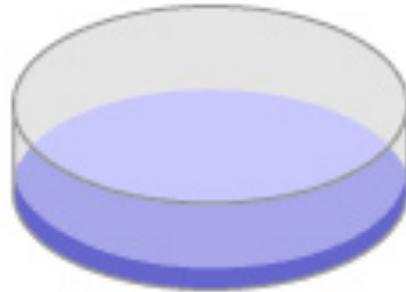


Early commercial development of plant GMO's used **antibiotic resistance** as a selection criterion, and used plasmid constructs in which the gene to be expressed in the transgenic crop plant, as well as the antibiotic resistance gene, were under control of the same promoter. Thus, the antibiotic resistance gene was expressed in the transgenic crop plant. More recently developed transgenic crops used BAPTA (herbicide) as a selectable marker, not antibiotic resistance.

**Testing whether the gene has been transferred**



Plants with new genes grow despite antibiotics



Cells without new genes are killed by antibiotics, so plants do not grow



‘Who is minding the store’? Should companies that develop new technologies that will impact the environment have public advisory councils?

It is often claimed that GMOs have reduced chemical use in agriculture. Is this correct? Not exactly.

Benbrook *Environmental Sciences Europe* 2012, 24:24  
<http://www.enveurope.com/content/24/1/24>

 Environmental Sciences Europe  
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## Impacts of genetically engineered crops on pesticide use in the U.S. – the first sixteen years

Charles M Benbrook

**Results:** Herbicide-resistant crop technology has led to a 239 million kilogram (527 million pound) increase in herbicide use in the United States between 1996 and 2011, while *Bt* crops have reduced insecticide applications by 56 million kilograms (123 million pounds). Overall, pesticide use increased by an estimated 183 million kgs (404 million pounds), or about 7%.

**Conclusions:** Contrary to often-repeated claims that today's genetically-engineered crops have, and are reducing pesticide use, the spread of glyphosate-resistant weeds in herbicide-resistant weed management systems has brought about substantial increases in the number and volume of herbicides applied. If new genetically engineered forms of corn and soybeans tolerant of 2,4-D are approved, the volume of 2,4-D sprayed could drive herbicide usage upward by another approximate 50%. The magnitude of increases in herbicide use on herbicide-resistant hectares has dwarfed the reduction in insecticide use on *Bt* crops over the past 16 years, and will continue to do so for the foreseeable future.

# CHANGING THE GLOBAL FOOD NARRATIVE

GMOs aren't giving the world more food

Changing diets, not population growth, is the driver of increased food demand

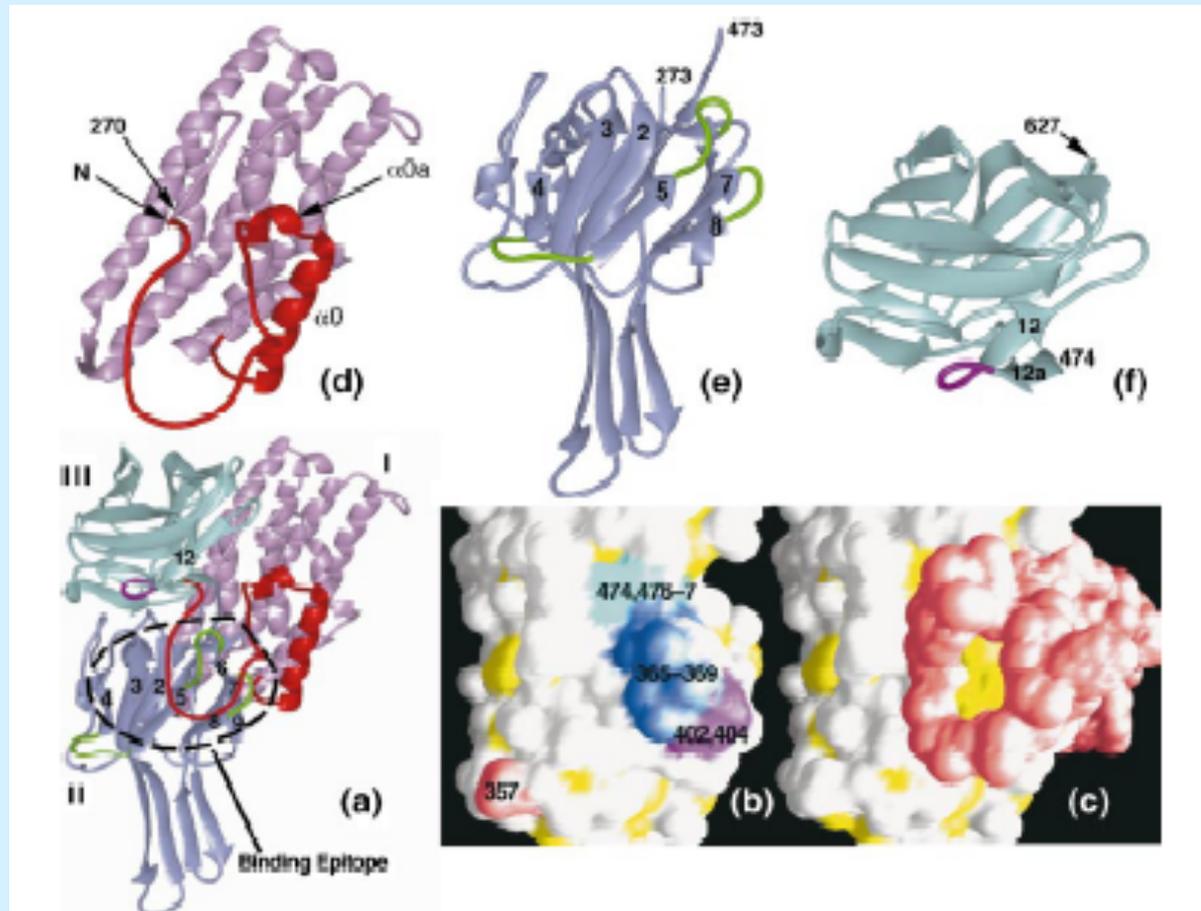
*The dominant story about the future of the world food supply is logical, well known and wrong.*

**by Jonathan Foley: Director, Calif. Acad. Sc.**

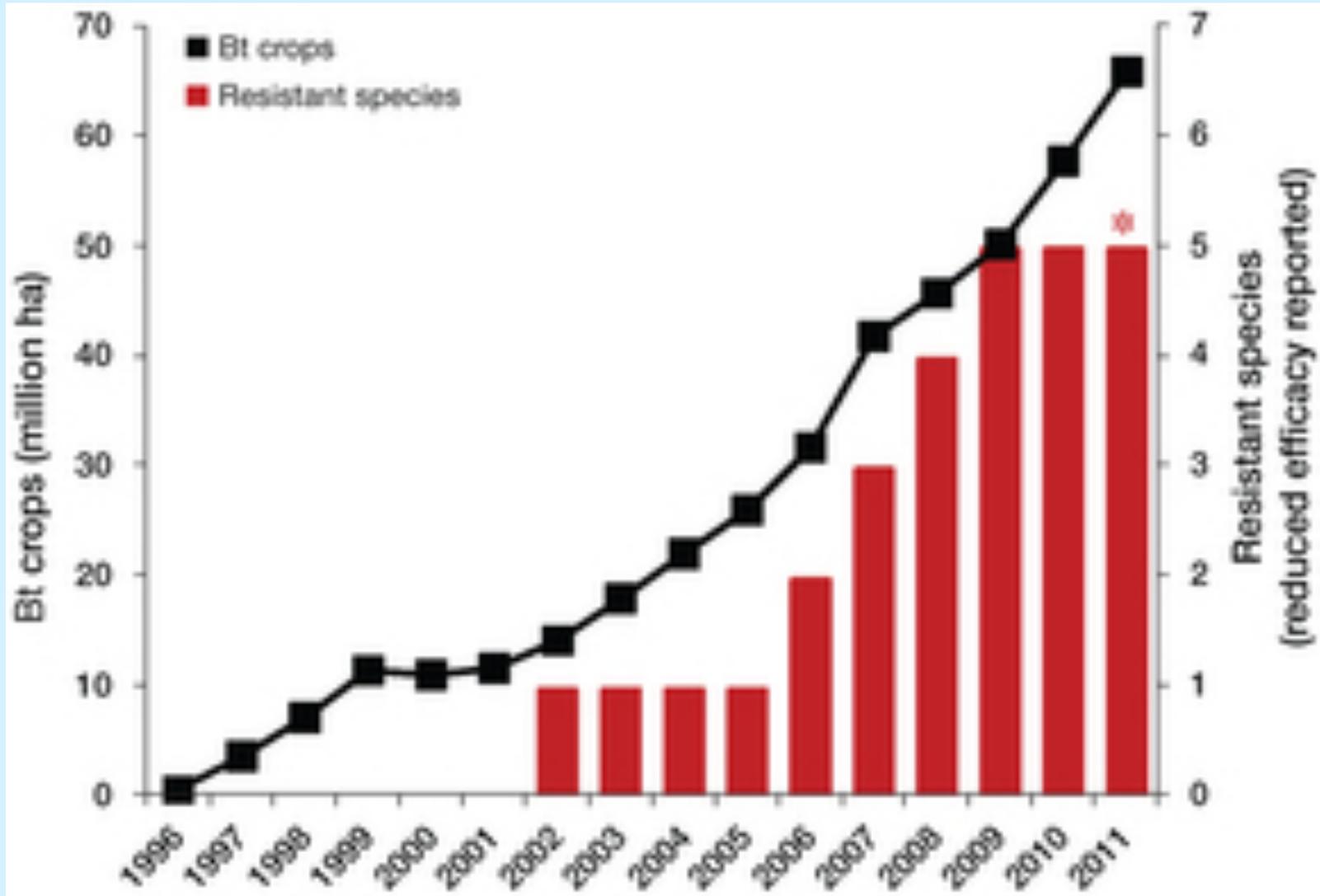


<http://ensia.com/voices/changing-the-global-food-narrative/>

BT protein: how it works, is it safe, can pests develop resistance? If insects have a specific receptor that binds the crystal BT protein, then the gene encoding the receptor could mutate. **Having a field of crop plants express the BT gene in every leaf, in all of the plant, for the entire life of the plant could create a tremendous selective pressure for insects which have mutations in the receptor gene to survive and pass on the mutation to progeny.**



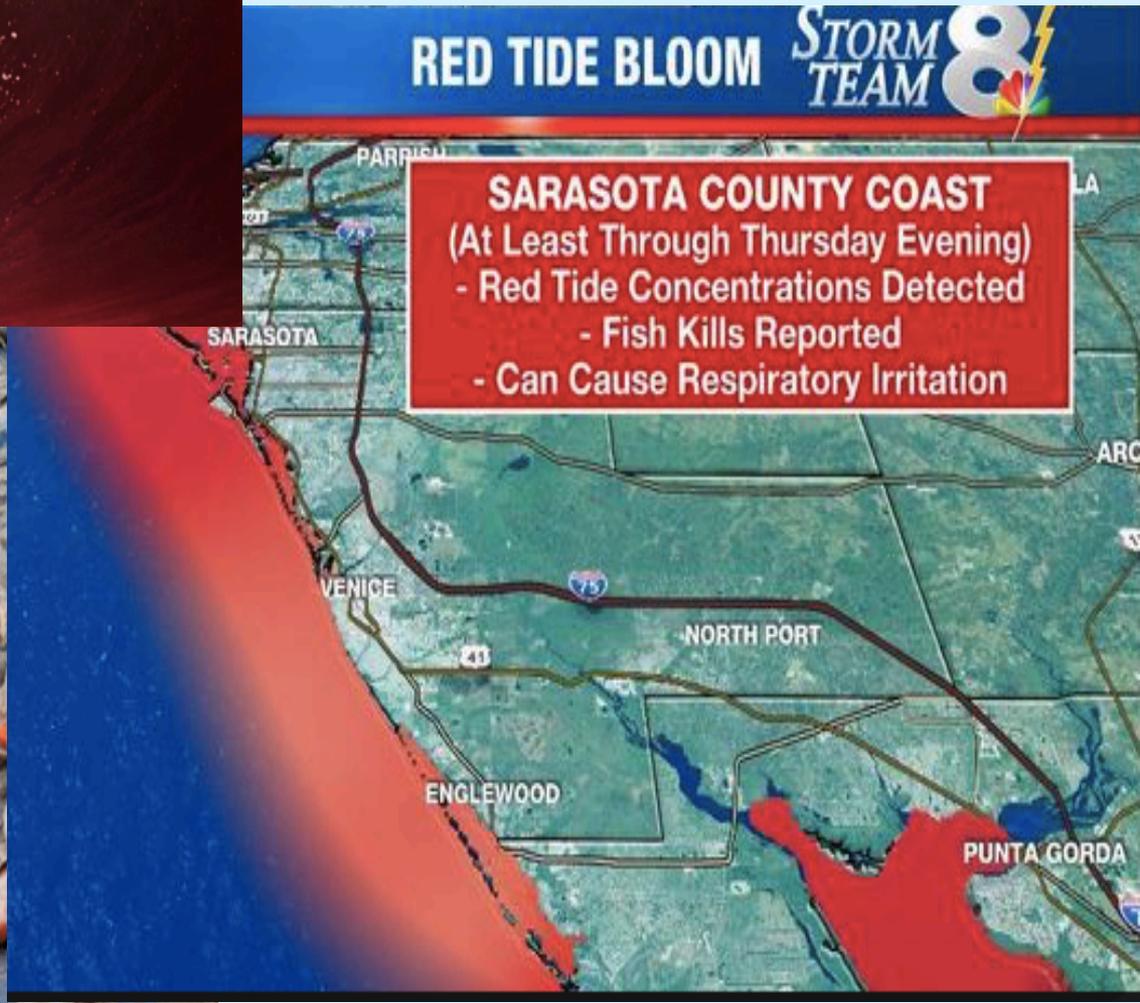
# Global adoption of Bt crops & evolution of insect resistance



Resistant species: bollworm, fall armyworm, stem borer



Red tide: in many cases, exacerbated by phosphate runoff from agriculture (sugar cane farming leads to  $\text{PO}_4$  in the Everglades). Question: Who pays for this?



# The Simple River-Cleaning Tactics That Big Farms Ignore

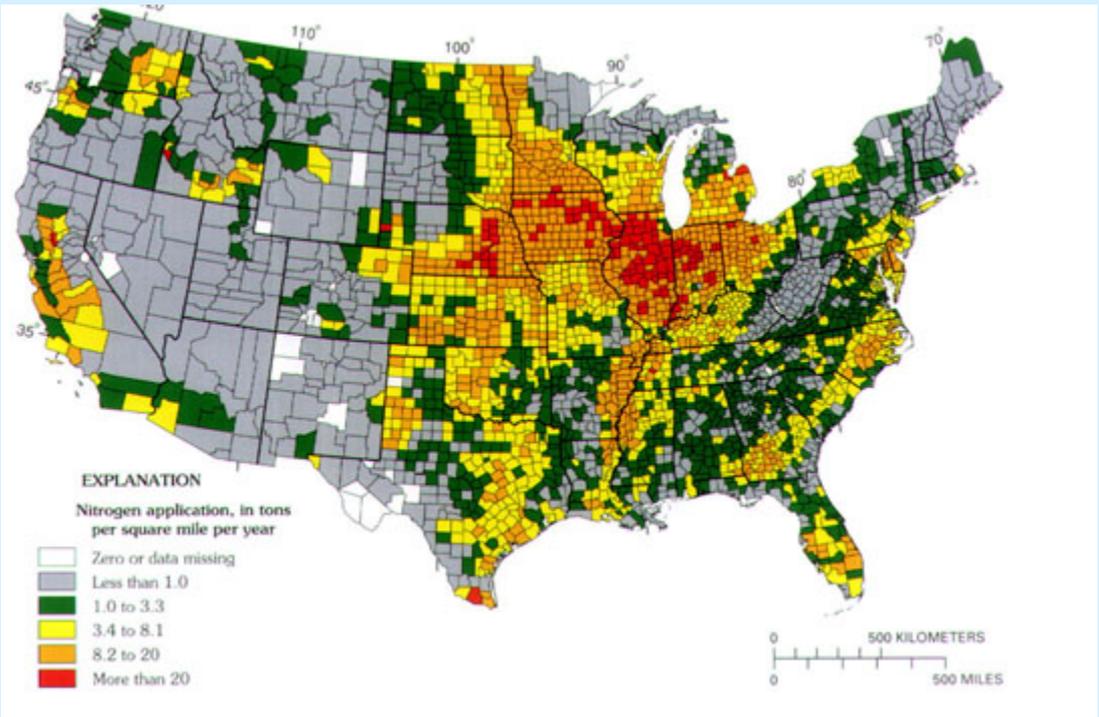
In Iowa and elsewhere, runoff from fertilized fields pollutes drinking water and creates dead zones.



## NATIONAL GEOGRAPHIC



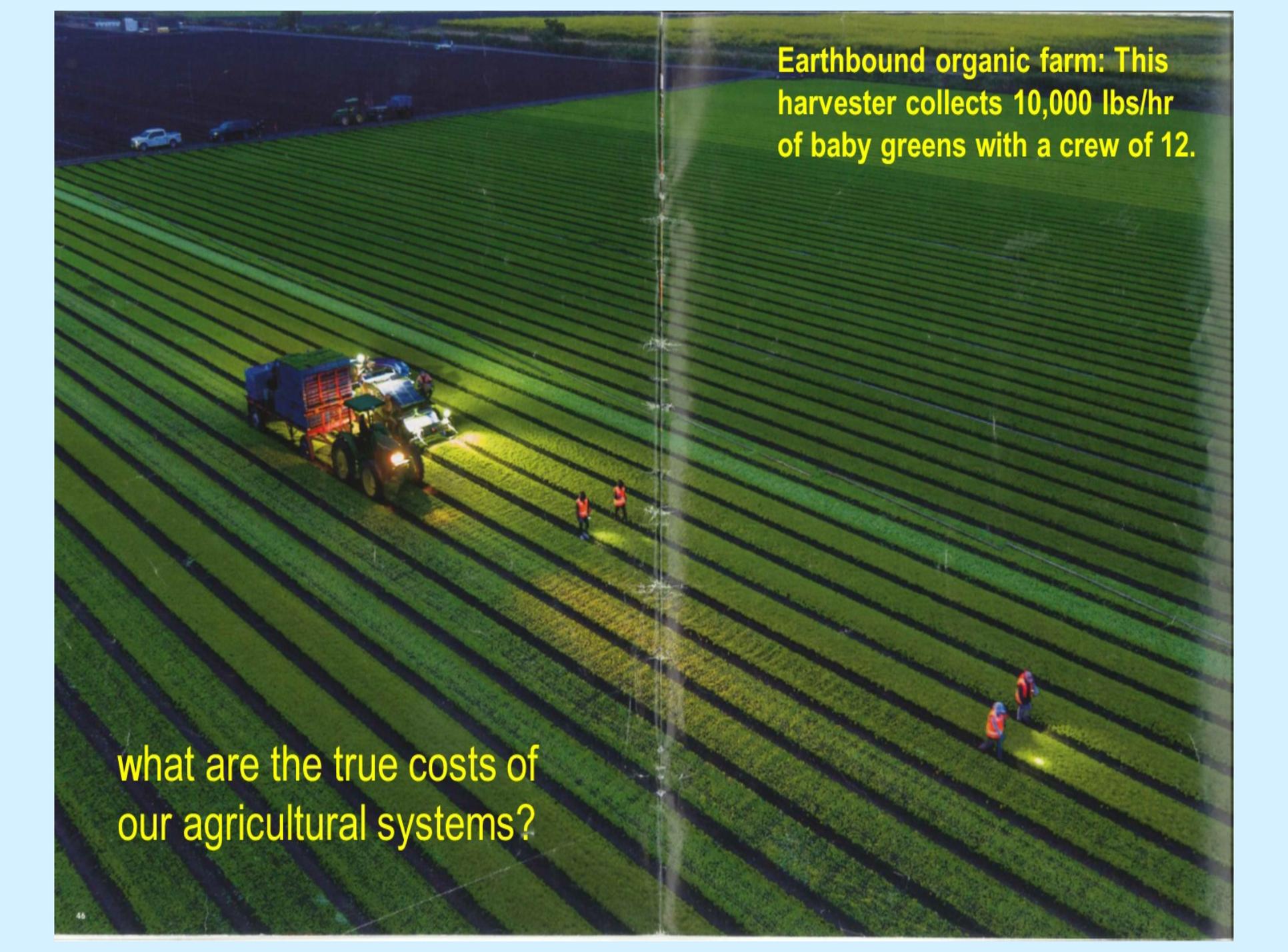
Mississippi River/Gulf of Mexico  
Watershed Nutrient Task Force  
2017 Report to Congress



80% of carrots we eat come from 2 farms. Bolthouse in CA has 60,000 acres. This plant processes 5 million lbs./day.

For many, where our food comes from, and how it is grown are important



An aerial photograph of a large-scale organic farm at night. The field is filled with neat, parallel rows of baby greens. A green tractor pulling a blue harvest trailer is moving through the rows, illuminated by its headlights. Several workers in orange safety vests are visible in the field, some standing near the tractor and others further down the rows. The overall scene is dark, with the primary light source being the tractor's headlights and some ambient light from the sky.

Earthbound organic farm: This harvester collects 10,000 lbs/hr of baby greens with a crew of 12.

what are the true costs of our agricultural systems?



# State of GMO Labeling

- State bills and ballot initiatives started to appear (e.g. California, Connecticut, Maine, Oregon and Washington) with varying requirements
  - Logistical and costs of retooling packing for one market
- Congress passed national labeling law preempting state standards
  - Directed USDA to establish a labeling standard



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## Information for Consumers

### Bioengineered Foods

- Retail food products that are bioengineered or contain bioengineered ingredients will say so on the label. Only foods that meet AMS's definition of bioengineered food will carry that disclosure.
- You will see words, a symbol (see Figure 1), scannable links, text message instructions, or in some cases phone numbers or web addresses that convey the information.



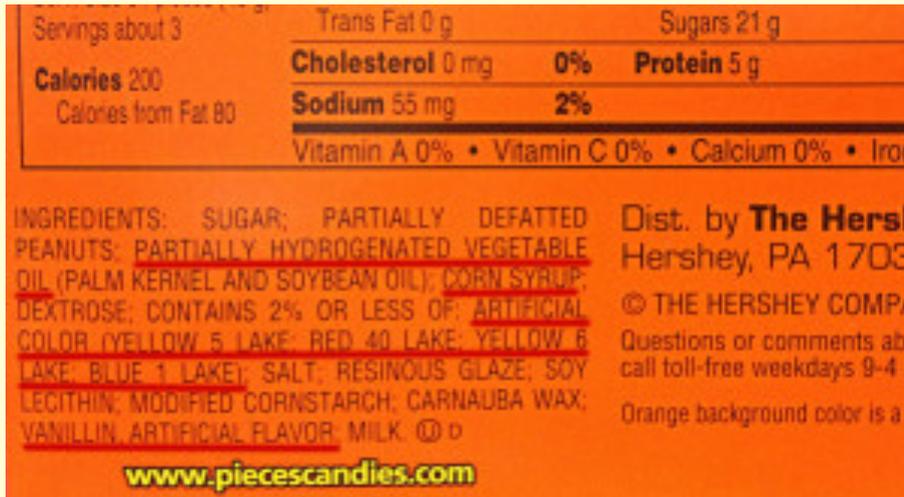
# State of GMO Labeling

- “bioengineered food . . . Shall not be treated as safer than, or not as safe as, a non-bioengineered counterpart.”
- 3 different labeling methods
- 1. Text on food packaging (e.g. “derived from bioengineering”)
- 2. Symbol that represents bioengineering
- 3. An electronic or digital link that can be scanned



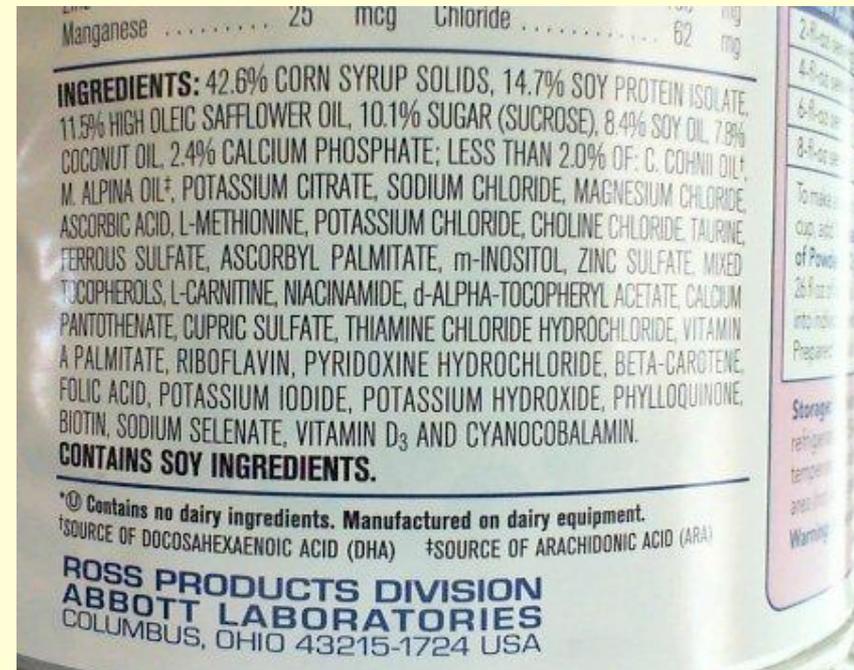
Why is there a continuing debate about the potential health risks of GMO crops? One can look to our a) our food labeling laws, b) the health food industry and what is sold in health food stores, and **wine labeling laws** in the US to understand the debate about GMOs. In the US, if something is marketed as a dietary supplement and it is a natural product (such as an extract from plants or dried plant parts), it can be sold without regulation- unless it can be shown to have adverse effects on human health.

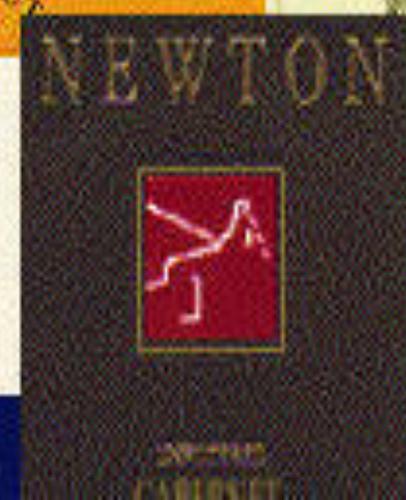
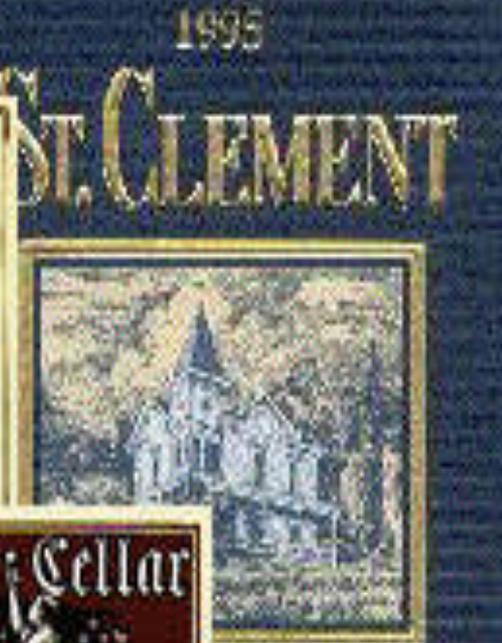
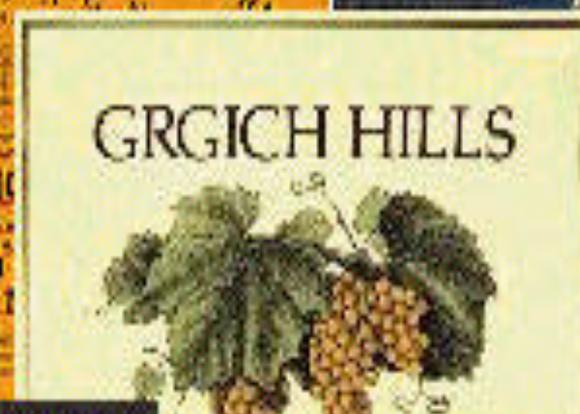
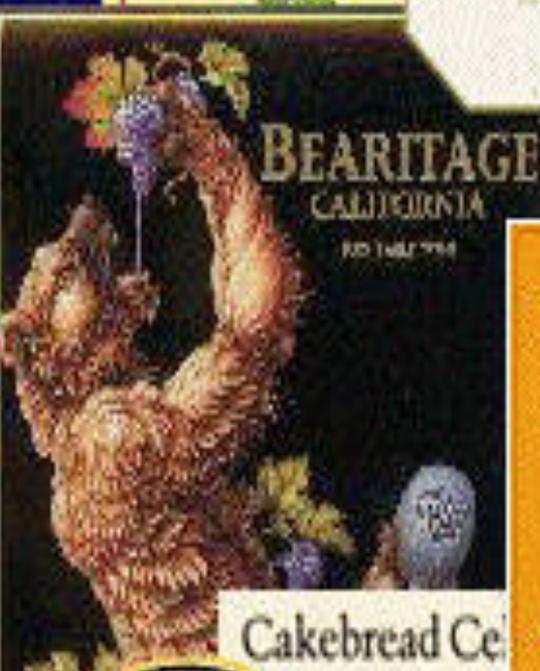
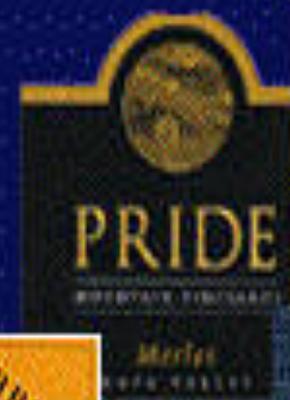
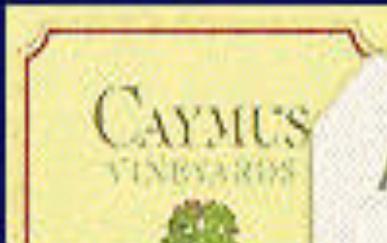
The case for labeling *GMO* Foods can be thought of as an extension of current food labeling laws. However, an analysis of exceptions to the food labeling laws for wine provide a context for what is happening with *GMO* labeling



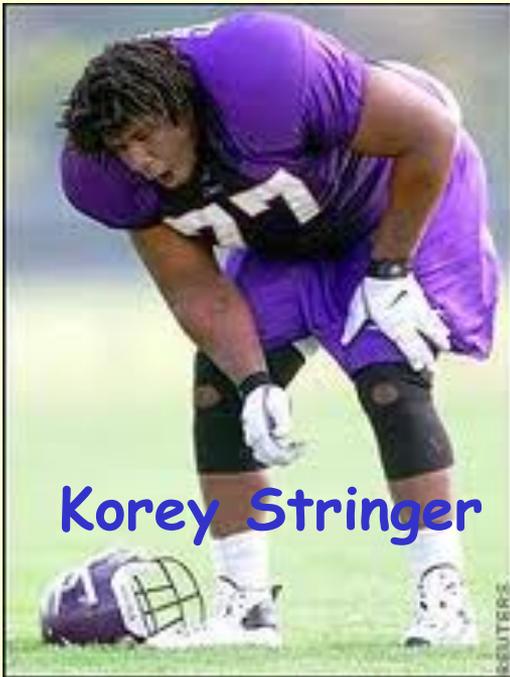
All processed food sold in the US is required to have a label listing ingredients in order by weight: is this correct?

Alcoholic beverages are under the jurisdiction of the Alcohol and Tobacco Tax and Trade Bureau (TTB), and are not required to have a nutrition facts label.

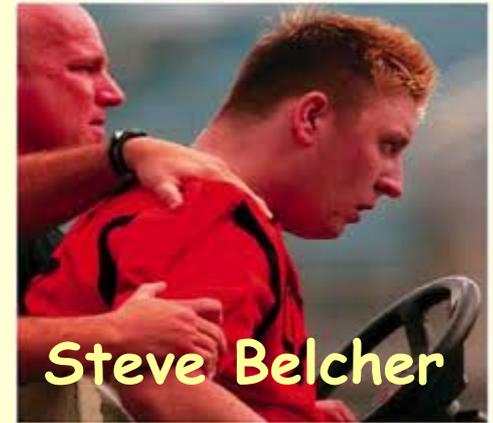
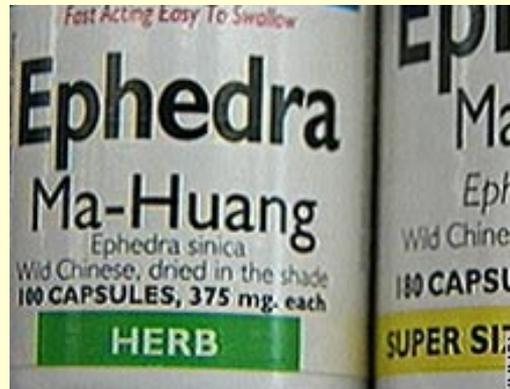




Ephedra and the FDA: What is sold at health food stores as 'dietary supplements' is completely unregulated. The alternative medicine 'movement' lobbied hard for this. Only after the FDA has evidence of a potential health risk, can a natural substance be regulated



Korey Stringer



Steve Belcher



Ephedra marketed as the supplement 'Ripped Fuel'

# Environmental and ecological issues

Gene escape:  
"superweeds"

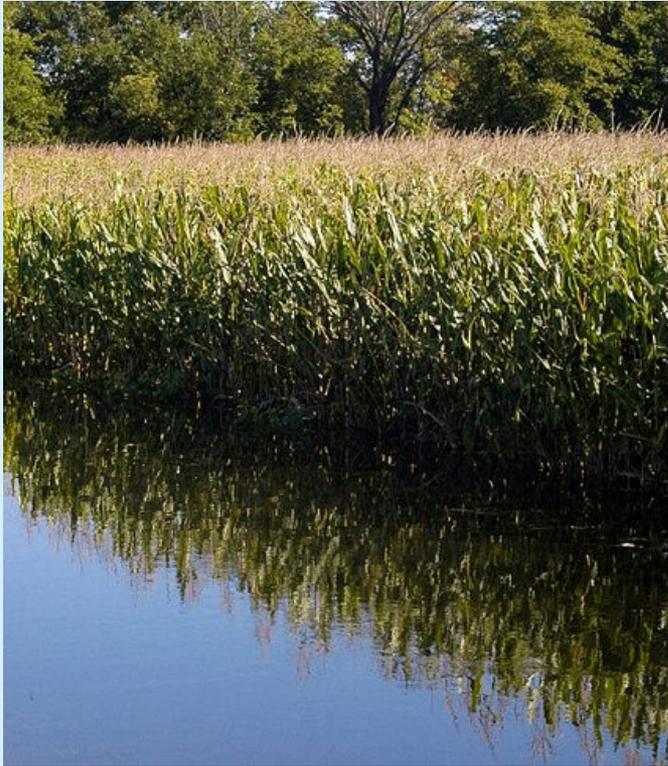
Impacts on  
non-target  
species



Insecticide  
resistance



Loss of biodiversity



## Conclusion

Are GM crops any worse than the rest of the technologies that underlie 'big' agriculture as it is practiced in the US today? I think that is an important question. Also important is an understanding of what monoculture, reliance on unsustainable cropping practices, long distance transport of foods, and hiding the true costs of crop production have on our environment and society.

