Labeling and Toxicity of Herbicides

Fred Fishel
Professor, UF/IFAS Agronomy
Outline

• History
  – Where we were and how we got here
• Toxicity testing
• Toxicity of herbicides and surfactant study
• Exposure and exposure study
• Storage and the 3-year old
Paracelsus (1493 – 1541)

Swiss physician, botanist, astrologer, alchemist, etc..

"All things are poison, and nothing is without poison; only the dose permits something not to be poisonous."

Or, more commonly

"The dose makes the poison."
Myth or Reality?

• Herbicides have been seen as toxins that poison plants and are equally harmful to the applicator.
Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

- “Iron or copper sulfate used at a rate of ½ to ¾ pound to 1 quart of water, and arsenate of soda used at the rate of 1 ounce to 6 quarts of water”
- “For applications to be made on the soil for the purpose of destroying root parts, common salt may be used – 8 ounces/ft²”
  - 10.9 tons per acre
Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

- “Arsenate of soda is a dangerous poison…”
- “Under no circumstances should he (applicator) permit any of the material to get into his mouth or nose. This danger can be overcome by wearing a small wet sponge or fine piece of cloth over the nose while working the sprayer.”
Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

- “Sulfuric, hydrochloric and nitric acids are positively destructive to the plant.”
- “…care must be exercised in their use, for they will burn clothing and flesh instantly. They will also result in blindness if spattered into the eyes.”
Killing field bindweed with sodium chlorate

Kansas State Agricultural College Circular 136 (1928)

• Salt
  – 20 tons per acre

• K.M.G. weed killer (sodium chlorate plus calcium chlorate)
  – 100 pounds in 100 gallons water per acre
The Control of Weeds

California Agricultural Extension Service Circular 54 (1931)

- According to San Joaquin County Agricultural Commissioner data, 2 men with a power sprayer cover 10 acres in 8 hours with 3,000 gallons oil.
  - Costs: oil at 3.75 cents per gallon
  - Labor: $10 per day
  - Total cost per acre including depreciation: $12.25
The Control of Weeds

California Agricultural Extension Service Circular 54 (1931)

• Chlorates are a fire hazard (oxidizer)
  – “Clothing, chaff, straw, sacks, wood, etc., covered with chlorate will readily ignite when dry.”
  – “Ashes from smoking tobacco, a match thoughtlessly lighted, or a spark from an exhaust pipe of spray equipment may set a fire.”
  – “Men should not work alone when using chlorates.”
Regulation Pre-1970

• By U.S. Department of Agriculture and Food and Drug Administration

• Legal to use any registered pesticide for any pest even if site and pest were not on the label
## Advancing Technology

### The Independent Discovery of 2,4-D

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Organization</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Templeman &amp; Associates</td>
<td>Imperial, U.K.</td>
<td>1940</td>
</tr>
<tr>
<td>Jones</td>
<td>American Chemical Paint, U.S.</td>
<td>Feb. 1942</td>
</tr>
</tbody>
</table>
Advancing Technology

- $2,4,5-T + 2,4-D = \text{Agent Orange}$
Advancing Technology

John Franz 1970
Discovered glyphosate

Weed control technology has advanced more in the previous million years than in any previous million years!

$5 for discovering glyphosate!
Advancing Technology

• Paul Müller: DDT (1939)
# Environmental Awareness Era

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Use</th>
<th>LD&lt;sub&gt;50&lt;/sub&gt; (rat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDT</td>
<td>Insecticide – flies, mosquitoes, ag insects &amp; rodents, etc.</td>
<td>87</td>
</tr>
<tr>
<td>Endrin</td>
<td>Insecticide – ag insects &amp; rodents</td>
<td>3</td>
</tr>
<tr>
<td>Mirex</td>
<td>Insecticide – fire ants</td>
<td>235</td>
</tr>
<tr>
<td>Chlordane</td>
<td></td>
<td>283</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>Insecticide – soil-borne insects (termites)</td>
<td>40</td>
</tr>
<tr>
<td>Dieldrin</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Aldrin</td>
<td></td>
<td>39</td>
</tr>
</tbody>
</table>
Environmental Awareness Era

- Publication of Silent Spring, by Rachel Carson in 1962, created an awareness of pesticide misuse
Environmental Awareness Era

• Silent Spring
  – Death of insect- and worm-eating birds
  – Massive destruction of the planet's fragile ecosystems
  – Death of non-target creatures
  – Must halt the “rain of chemicals”

U.S. Secretary of Agric. Ezra Taft Benson in a letter to President Dwight D. Eisenhower: concluded that because Carson was unmarried despite being physically attractive, she was “probably a Communist.”
Environmental Awareness Era

• Silent Spring
  – Never advocated a complete ban of all pesticides
  – Encouraged responsible and carefully managed use with an awareness of the chemicals’ impact on the entire ecosystem
  – Advised for spraying as little as possible to limit the development of resistance
Environmental Awareness Era

- Formation of EPA (1970)

Periled Pesticide

Wisconsin Hearing on Bid to Ban DDT Could Affect Future of All Such Products

BY RICHARD D. JAMES

THE WALL STREET JOURNAL, Tuesday, March 4, 1969

Periled Pesticide

Wisconsin Hearing on Bid to Ban DDT Could Affect Future of All Such Products

BY RICHARD D. JAMES

N.Y.-based group comprised mainly of scientists that has waged a steady battle against DDT and similar insecticides, chiefly in the courts, ever since it was formed in October 1957.

It has met only limited success in the courts, but its lawsuits against state and local agencies haven’t been totally ineffectual. Among other things, the pressure the suits have generated is credited with prompting more than 50 cities in Michigan to stop using DDT against the Dutch elm disease.

The industry is fighting back through a DDT task force, organized several years ago under the aegis of the National Agricultural Chemicals Association to contain the brush fires ignited by DDT’s opponents. Most of its members are the companies that make DDT: Diamond Shamrock Corp., Allied Chemical Corp., Olin Mathieson Chemical Corp., Lebanon Chemical Corp., a privately held company, and Montrose Chemical Corp. of California, the largest maker. Montrose is owned jointly by Chris-Craft Industries Inc. and Stoughton Chemical Co. A sixth member, Geigy Chemical Corp., Airdale, N.Y., doesn’t make DDT.

Caught Off Balance

Thus, the industry is well organized to defend itself, but the Wisconsin attack seemingly caught it off balance. The task force didn’t realize pesticides aren’t as effective and because they are shorter-lived they must be applied more often, increasing the chances for improper and harmful use. Resides, industry spokesmen say, DDT is safe. It must be approved by the Federal Government, they assert, and the Government agencies involved—the departments of Agriculture and Interior and the Food and Drug Administration—wouldn’t approve any agent harmful to humans or wildlife.

The industry backs up its contentions on safety by citing a study of Montrose Chemical employees at a DDT plant. The study reports the employees are exposed to much higher levels of DDT than is the general public, yet they don’t show any signs of harmful effects.

Possible Effect on Humans

So far, the issue of DDT’s effects on humans hasn’t been raised directly in the hearings. It was touched on briefly, though, by two witnesses. Richard Welch, a pharmacologist with Burroughs Wellcome & Co., a drug manufacturer, said the sex hormones affected in rats by the DDT-activated enzymes are the same ones found in man. He also explained that the amount of DDT needed to produce the effect is within a range of DDT found in human fat. . . . Thus, if one can extrapolate data from animals to man, then one would say that the change in those hormones probably
Environmental Awareness Era

DDT Ban Takes Effect

[EPA press release - December 31, 1972]

The general use of the pesticide DDT will no longer be legal in the United States after today, ending nearly three decades of application during which time the once-popular chemical was used to control insect pests on crop and forest lands, around homes and gardens, and for industrial and commercial purposes.

An end to the continued domestic usage of the pesticide was decreed on June 14, 1972, when William D. Ruckelshaus, Administrator of the Environmental Protection Agency, issued an order finally cancelling nearly all remaining Federal registrations of DDT products. Public health, quarantine, and a few minor crop uses were excepted, as well as export of the material.

The effective date of the EPA June cancellation action was delayed until the end of this year to permit an orderly transition to substitute pesticides, including the joint development with the U.S. Department of Agriculture of a special program to instruct farmers on safe use of substitutes.

The cancellation decision culminated three years of intensive governmental inquiries into the uses of DDT. As a result of this examination, Ruckelshaus said he was convinced that the continued massive use of DDT posed unacceptable risks to the environment and potential harm to human health.

Major legal challenges to the EPA cancellation of DDT are now pending before the U.S. Court of Appeals for the District of Columbia and the Federal District Court for the Northern District of...
Environmental Awareness Era

- FIFRA amended (1972)
  - Essentially rewritten
  - Mandates that EPA regulate the use and sale of pesticides
  - Strengthen the registration process by shifting the burden of proof to the chemical manufacturer (140 – 150 tests required to pass registration)
  - Enforce compliance against banned and unregistered products
  - Established an applicator education/licensing program
  - Each state given authority to enforce
## Then and Now

<table>
<thead>
<tr>
<th>THEN (Carson’s concerns)</th>
<th>NOW (EPA answers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast</td>
<td>Directed, spot</td>
</tr>
<tr>
<td>High Rate (gal, lb)</td>
<td>¼ oz/acre, 5-10 ppb</td>
</tr>
<tr>
<td>Persistent (mos, yrs)</td>
<td>Hours, days, weeks</td>
</tr>
<tr>
<td>Bioaccumulate</td>
<td>Not likely to be approved</td>
</tr>
<tr>
<td>Unknown effects</td>
<td>Much less likely</td>
</tr>
<tr>
<td>Untrained applicators</td>
<td>2,500 Florida Certified (Aquatic)</td>
</tr>
</tbody>
</table>
Food Quality Protection Act of 1996

• Significantly amended FIFRA and FFDCA
• Emphasized safety for infants and children
  – EPA adds 10x safety factor to tolerance settings for protection of infants and children
Testing Requirements for Registration

Efficacy:
- High degree of biological efficacy
- Broad spectrum of efficacy
- Good plant compatibility
- Low risk for resistance development

User friendly:
- Low acute and chronic toxicity
- Good formulation qualities
- Easy to handle
- Low application rate
- Good storage stability

Environmental profile:
- Low toxicity to non-target organisms
- Sufficient degradation in soil
- Low leaching
- No significant residues in food and animal feed

Economy:
- Favorable cost/benefit ratio
- Competitiveness
- Broad spectrum of uses
- Patentability

The Innovative Product

The registration cost is $152 - $256 million per product – 1 in 139,000 make it.
The Development of Sonar

EUP granted in 1980 and fully registered in 1985!

• 1974-75: Discovery
• 1975-82: Environmental fate studies
  1975-78: C\textsubscript{14} nature in plants
• 1975-77: Acute toxicology
• 1975-76: Subchronic toxicology
• 1976-83: Efficacy and use patterns for aquatics
• 1976-81: C\textsubscript{14} soil metabolism studies
• 1976-81: Chronic toxicity/oncogenousity studies
• 1977-83: Residue studies in plants and irrigated crops
• 1978-79: C\textsubscript{14} animal metabolism studies
• 1978-85: Residue studies in fish, livestock, poultry, milk, and eggs
• 1978-81: Avian, aquatic, and nontarget organism toxicity
• 1978-80: Reproduction/teratological studies
• 1979-80: Residue in potable water and mutagenicinity studies

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UNIVERSITY OF FLORIDA
Toxicity

• The ability of a substance to produce adverse effects
  – Range from slight symptoms such as headaches to severe symptoms like coma, convulsions, or death
  – Most toxic effects are naturally reversible and do not cause permanent damage if prompt medical treatment is sought
  – Some cause irreversible (permanent) damage
Toxicity Testing

- All new pesticides are tested to establish the type of toxicity and the dose necessary to produce a measurable toxic reaction
- Testing is done with animals and plants
  - Generally in mice, rats, rabbits, and dogs
  - Results are used to predict the safety to humans
Toxicity Testing

- Toxicty tests are based on two premises
  1. Information about toxicity in animals can be used to predict toxicity in human
  2. Exposing animals to large doses of a chemical for short periods of time can predict human toxicity from exposure to small doses for long periods of time
- Both premises have been questioned
Toxicity Testing

Purdue Pesticide Programs
Toxicity Testing

NOEL = no observed effect level
LOEL = lowest observed effect level
Plateau = level where there's no increase in response
Toxicity Testing

• Interpreting dose-response relationships:
  – No single dose-response curve can describe the entire range of toxicological responses exhibited by an experimental animal
  – End points may be indirect indicators of toxicity such as observations in behavior or food consumption patterns
  – The dose required to produce a given effect (end point) may vary, depending on the pesticide
Toxicity Testing

- Data used to develop dose-response curves are unique to the test animal.
- Dose-response curves may differ depending on the route of exposure: oral, dermal, or inhalation.
Toxicity

**LC\(_{50}\): common term to describe lethal concentration**

- Used with aquatic herbicides since fish and aquatic organisms are in direct contact with water
- Test organisms are exposed for 96 hours
  - Commonly conducted with bluegill
- \(LC_{50}\) = lethal concentration of herbicide to 50% of the test population
- Measured in mg/l (ppm)

**High Toxicity = Low \(LC_{50}\)**
## Toxicity - Bluegill (Submersed Herbicides)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>LC$_{50}$ (Mg/L)</th>
<th>Use Rate (ppm)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diquat</td>
<td>14</td>
<td>0.4</td>
<td>35X</td>
</tr>
<tr>
<td>Fluridone</td>
<td>14</td>
<td>0.02</td>
<td>700X</td>
</tr>
<tr>
<td>Flumioxazin</td>
<td>$&gt;21$</td>
<td>0.4</td>
<td>53X</td>
</tr>
<tr>
<td>Endothall K</td>
<td>1071</td>
<td>3</td>
<td>350X</td>
</tr>
</tbody>
</table>
What the Heck is a Daphnia?

- Planktonic crustacean
- Aka water flea
- Eats algae
- Indicator species to test the effects of toxins
### Toxicity - Daphnia (Submersed Herbicides)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>LC$_{50}$ (Mg/L)</th>
<th>Use Rate (ppm)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endothall K</td>
<td>223</td>
<td>2.0-3.0</td>
<td>100X</td>
</tr>
<tr>
<td>Fluridone</td>
<td>6</td>
<td>0.02</td>
<td>300X</td>
</tr>
<tr>
<td>Flumioxazin</td>
<td>6</td>
<td>0.4</td>
<td>15X</td>
</tr>
<tr>
<td>Diquat</td>
<td>1</td>
<td>0.4</td>
<td>2X</td>
</tr>
</tbody>
</table>
Toxicity of Surfactants to Bluegill

- Interest in aquatic use adjuvants initiated when Rodeo was introduced by Monsanto in early 1980s
- Label instructed user to add nonionic surfactant of user’s choice
- 96-hr bioassay in controlled conditions for 19 adjuvants
- Conducted in 7 l of aerated well water
- Adjuvants introduced 24-hr prior to fish
- 10 juvenile fish added per aquarium
- LC$_{50}$ values calculated

# Toxicity of Surfactants to Bluegill

<table>
<thead>
<tr>
<th>Product</th>
<th>Class</th>
<th>LC$_{50}$ (Mg/L)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON 0818</td>
<td>Tallow Amine</td>
<td>1.6</td>
<td>NA</td>
</tr>
<tr>
<td>Optima</td>
<td>Alcohol/Glycol</td>
<td>8.6</td>
<td>9X</td>
</tr>
<tr>
<td>Induce</td>
<td>Limonene</td>
<td>9.0</td>
<td>19X</td>
</tr>
<tr>
<td>Timberland</td>
<td>Limonene</td>
<td>9.6</td>
<td>20X</td>
</tr>
<tr>
<td>Cide-Kick</td>
<td>Limonene</td>
<td>10.2</td>
<td>6X</td>
</tr>
<tr>
<td>SilEnergy</td>
<td>Silicone</td>
<td>18</td>
<td>38X</td>
</tr>
<tr>
<td>Kinetic</td>
<td>Silicone</td>
<td>20</td>
<td>42X</td>
</tr>
<tr>
<td>Dynamic</td>
<td>Silicone</td>
<td>27</td>
<td>38X</td>
</tr>
<tr>
<td>Freeway</td>
<td>MSO</td>
<td>30</td>
<td>63X</td>
</tr>
<tr>
<td>Sunwet</td>
<td>MSO</td>
<td>53</td>
<td>113X</td>
</tr>
</tbody>
</table>
# Toxicity of Surfactants to Bluegill

## Surfactant summary by chemical group

<table>
<thead>
<tr>
<th>Surfactant Group</th>
<th>LC$_{50}$ (Mg/L) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tallow Amines</td>
<td>1-3 ppm</td>
</tr>
<tr>
<td>Alcohol Glycols</td>
<td>4-10 ppm</td>
</tr>
<tr>
<td>Silicones</td>
<td>10-30 ppm</td>
</tr>
<tr>
<td>Meth Seed</td>
<td>50-60 ppm</td>
</tr>
<tr>
<td>Acids/Buffers</td>
<td>100-200 ppm</td>
</tr>
</tbody>
</table>

**Assumptions:**
- Maximum Label Rate
- Uniformly mixed in 3.3ft (1M) of water

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Toxicity of Surfactants to Bluegill

• Other factors could change these results:
  – Application in shallow water
  – Use of more sensitive test species
    • Daphnia
    • Larval stage bluegill
  – Water quality factors
    • pH
    • Hardness

Acute Toxicity

- LD$_{50}$: common term to describe acute oral toxicity
- Acute toxicity tests measure mortality following a single exposure
- LD$_{50}$: dose that’s acutely lethal to 50% of the test population of animals
Acute Toxicity

- LD$_{50}$ is commonly expressed as mg of toxin per kg of test animal body weight (mg/kg)
- LD$_{50}$ of 500 mg/kg is less toxic than LD$_{50}$ of 5 mg/kg
- 1 kg = 1,000 g = 2.2 lb
- 1 mg = 0.001 kg = 0.0022 lb
- Mg/kg = ppm
- 1 ppm = 1 inch in 16 miles or 1 minute in 2 years
• LD$_{50}$ values for a single chemical can vary by:
  – Route of exposure
  – Test species

<table>
<thead>
<tr>
<th>Dichlorvos LD$_{50}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral LD$_{50}$ (rat)</td>
</tr>
<tr>
<td>Dermal LD$_{50}$ (rat)</td>
</tr>
<tr>
<td>Inhalation LC$_{50}$ (rat)</td>
</tr>
<tr>
<td>Oral LD$_{50}$ (rabbit)</td>
</tr>
<tr>
<td>Oral LD$_{50}$ (pigeon)</td>
</tr>
<tr>
<td>Oral LD$_{50}$ (dog)</td>
</tr>
<tr>
<td>Oral LD$_{50}$ (pig)</td>
</tr>
</tbody>
</table>

Dichlorvos is an insecticide commonly used in household pesticide strips
### Acute Toxicity

The signal word is determined by the most severe toxicity category assigned to the five acute toxicity studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Category I</th>
<th>Category II</th>
<th>Category III</th>
<th>Category IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Oral</td>
<td>Up to and including 50 mg/kg</td>
<td>&gt; 50 thru 500 mg/kg</td>
<td>&gt; 500 thru 5000 mg/kg</td>
<td>&gt; 5000 mg/kg</td>
</tr>
<tr>
<td>Acute Dermal</td>
<td>Up to and including 200 mg/kg</td>
<td>&gt; 200 thru 2000 mg/kg</td>
<td>&gt; 2000 thru 5000 mg/kg</td>
<td>&gt; 5000 mg/kg</td>
</tr>
<tr>
<td>Acute Inhalation(^1)</td>
<td>Up to and including 0.05 mg/liter</td>
<td>&gt; 0.05 thru 0.5 mg/liter</td>
<td>&gt; 0.5 thru 2 mg/liter</td>
<td>&gt; 2 mg/liter</td>
</tr>
<tr>
<td>Primary Eye Irritation</td>
<td>Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days</td>
<td>Corneal involvement or other eye irritation clearing in 8-21 days</td>
<td>Corneal involvement or other eye irritation clearing in 7 days or less</td>
<td>Minimal effects clearing in less than 24 hours</td>
</tr>
<tr>
<td>Primary Skin Irritation</td>
<td>Corrosive (tissue destruction into the dermis and/or scarring)</td>
<td>Severe irritation at 72 hours (severe erythema or edema)</td>
<td>Moderate irritation at 72 hours (moderate erythema)</td>
<td>Mild or slight irritation at 72 hours (no irritation or slight erythema)</td>
</tr>
</tbody>
</table>

\(^1\) 4 hr exposure
## Acute Toxicity

<table>
<thead>
<tr>
<th>Categories</th>
<th>Signal Word</th>
<th>Oral Lethal Dose&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Highly toxic</td>
<td>DANGER, POISON</td>
<td>A few drops to a teaspoon</td>
</tr>
<tr>
<td>II Moderately toxic</td>
<td>WARNING</td>
<td>Over a teaspoon to one ounce</td>
</tr>
<tr>
<td>III Slightly toxic</td>
<td>CAUTION</td>
<td>Over one ounce to one pint</td>
</tr>
<tr>
<td>IV Relatively non-toxic</td>
<td>CAUTION (or no signal word)</td>
<td>Over one pint to one pound</td>
</tr>
</tbody>
</table>

<sup>1</sup>Probable for a 150 pound person.
How Do Herbicides Work?

- They inhibit essential plant process:
  - Photosynthesis
  - Chlorophyll
  - Certain amino acids
  - Cell wall
<table>
<thead>
<tr>
<th>Substance</th>
<th>Acute oral LD$_{50}$ (rat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicotine</td>
<td>9</td>
</tr>
<tr>
<td>Caffeine</td>
<td>192</td>
</tr>
<tr>
<td>Bleach</td>
<td>192</td>
</tr>
<tr>
<td>Aspirin</td>
<td>200</td>
</tr>
<tr>
<td>Tylenol</td>
<td>338</td>
</tr>
<tr>
<td>Codeine</td>
<td>427</td>
</tr>
<tr>
<td>Table salt</td>
<td>3,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product (active ingredient)</th>
<th>Acute oral LD$_{50}$ (rat)/signal word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquathol K (endothall potassium salt)</td>
<td>182/DANGER*</td>
</tr>
<tr>
<td>Reward (diquat)</td>
<td>886/CAUTION</td>
</tr>
<tr>
<td>Weedar (2,4-D)</td>
<td>&gt;1,000/DANGER*</td>
</tr>
<tr>
<td>Captain (copper carbonate)</td>
<td>&gt;1,000/CAUTION</td>
</tr>
<tr>
<td>Oasis (topramezone)</td>
<td>&gt;2,000/CAUTION</td>
</tr>
<tr>
<td>Renovate (triclopyr)</td>
<td>2,574/DANGER*</td>
</tr>
<tr>
<td>Tradewind (bispyribac-sodium)</td>
<td>4,111 (males)/CAUTION</td>
</tr>
<tr>
<td>Habitat (imazapyr)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Galleon (penoxsulam)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Clearcast (imazamox)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Clipper (flumioxazin)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Rodeo (glyphosate)</td>
<td>5,600/CAUTION</td>
</tr>
<tr>
<td>Sonar AS (fluridone)</td>
<td>&gt;10,000/CAUTION</td>
</tr>
</tbody>
</table>

*Corrosive
## Acute Toxicity Determines PPE

<table>
<thead>
<tr>
<th>Route of Exposure</th>
<th>I Danger</th>
<th>II Warning</th>
<th>III Caution</th>
<th>IV Caution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dermal Toxicity or Skin Irritation Potential</strong></td>
<td>Coveralls worn over long sleeved shirt and long pants&lt;br&gt;Socks&lt;br Chemical-resistant footwear&lt;br&gt;Gloves</td>
<td>Long sleeved shirt and long pants</td>
<td>Long sleeved shirt and long pants&lt;br&gt;Socks</td>
<td>Long sleeved shirt and long pants&lt;br&gt;Socks&lt;br&gt;Shoes&lt;br&gt;Gloves&lt;br&gt;No minimum</td>
</tr>
<tr>
<td><strong>Inhalation Toxicity</strong></td>
<td>Respiratory protection device</td>
<td></td>
<td></td>
<td>No minimum</td>
</tr>
<tr>
<td><strong>Eye Irritation Potential</strong></td>
<td>Protective eyewear</td>
<td></td>
<td>No minimum</td>
<td>No minimum</td>
</tr>
</tbody>
</table>
The LD$_{50}$ Determines...

**PPE**

**Signal Word**

**Precautionary Statements**

**First Aid**
# Most Acute Reported Pesticide Illnesses to a Single Substance (2005-09)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Pesticide category</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pyrethroids</td>
<td>1,368</td>
<td>22.1</td>
</tr>
<tr>
<td>2</td>
<td>Chlorinated compounds</td>
<td>1,174</td>
<td>19.0</td>
</tr>
<tr>
<td>3</td>
<td>Organophosphates</td>
<td>600</td>
<td>9.7</td>
</tr>
<tr>
<td>4</td>
<td>Pyrethrins</td>
<td>358</td>
<td>5.8</td>
</tr>
<tr>
<td>5</td>
<td>DEET</td>
<td>292</td>
<td>4.7</td>
</tr>
<tr>
<td>6</td>
<td>Glyphosate</td>
<td>274</td>
<td>4.4</td>
</tr>
<tr>
<td>7</td>
<td>Carbamates</td>
<td>249</td>
<td>4.0</td>
</tr>
<tr>
<td>8</td>
<td>Triazines</td>
<td>168</td>
<td>2.7</td>
</tr>
<tr>
<td>9</td>
<td>Sulfur compounds</td>
<td>145</td>
<td>2.3</td>
</tr>
<tr>
<td>10</td>
<td>Ammonium/ammonia</td>
<td>32</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>6,187</td>
<td></td>
</tr>
</tbody>
</table>
I spray herbicides every day.... What is my exposure if I do everything correctly?

Smith, J.D. and H. Pullum. 1994. Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs. Aquatics 16(1):14-16
Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs

• Methods.....
  – 5 independent tests (2,4-D and diquat)
  – Conducted: Okeechobee, Clewiston, and Kissimmee
  – Glass filter on Tyvek lapels of both airboat driver and applicator
  – Suction pump air flow rate of 1 to 3 L/min (NIOSH 2,4-D test protocol standard)
    • OSHA test protocol used for diquat
  – Tested for 2 to 6+ hours exposure

Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs

2,4-D

<table>
<thead>
<tr>
<th>Person</th>
<th>Hours Exposed</th>
<th>Avg. Conc. (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>4.5</td>
<td>&lt;0.06 (60 ppt)</td>
</tr>
<tr>
<td>Sprayer</td>
<td>4.4</td>
<td>&lt;0.06</td>
</tr>
</tbody>
</table>

OSHA Permissible Exposure Limit = 10 mg/m³ (SF = 166X)

Diquat

<table>
<thead>
<tr>
<th>Person</th>
<th>Hours Exposed</th>
<th>Avg. Conc. (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>4.1</td>
<td>&lt;0.02 (20 ppt)</td>
</tr>
<tr>
<td>Sprayer</td>
<td>4.3</td>
<td>&lt;0.02</td>
</tr>
</tbody>
</table>

OSHA Permissible Exposure Limit = 0.5 mg/m³ (SF = 25X)

Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs

Why such low exposure?

• Spray concentration <1% (<1gallon/100gallons)
• Spray directed from side of boat at idle speed
• Prevailing wind and idle speed combined to create a dilution/ventilation system to pull mist away from the breathing zone

Regardless of pesticide risk – storage is the same for all
Consider these.....

• Would you ever store herbicides, even those with Caution labels, within reach of children?

• Would you ever allow pesticides near where you prepare food?
Under the kitchen sink at Stephen Enloe’s house,
The children at Stephen Enloe’s house
What’s the difference in these?

- Restricted use
- Must be licensed and trained to purchase
- Stored behind locked door with vent fan

- Anyone can purchase
- Can be stored anywhere
In your laundry room.....
In the garage at Stephen Enloe’s house
In the garage at Stephen Enloe’s house
National Poison Control Centers Summary (2014)

People of All Ages
• 2.2 million calls total
  – 83,000 Pesticides Total (3%)

Children 0-5 Years Old
– 1.3 million total Calls (60%)
  • 147,000 Cosmetics (15%)
  • 114,000 Household cleaning substances (11%)
  • 92,000 Painkillers (9%)
  • 34,000 Pesticides (3%) – 8th out of the 25 most common substance categories
Summary

- Risk = f(Toxicity x Exposure)
- Don’t get complacent

Point is this:
We are surrounded by “toxins”
Pesticides have greatly changed

* Train or have trained employees
* Provide PPE
* Store pesticides properly
* Emphasize use according to labeling
* Re-think household chemical storage
Thanks for your attention!