Assessing the Hazards/Risks
Herbicides Pose to Fish and Wildlife

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Presentation Outline

• Considerations in assessing hazards/risks:
  o Importance of context in extrapolating laboratory toxicity data to the field

• Example of integrating ecological and operational contexts into toxicity testing
  o Assessing the hazards aquatic herbicides pose to amphibians

• Final thoughts
Why Is Context Important?

Key to Hazard and Risk Assessment

- Environmental exposure
- Environmental, ecological, operational contexts
- Extrapolation of laboratory toxicity data to the field
- Improving design of laboratory toxicity tests

\[
\text{Hazard} = \text{Toxicity} + \text{Environmental Exposure}
\]

\[
\text{Risk} = \text{Probability} \text{ of hazard being realized}
\]

These contexts are also critical to evaluating indirect effects
Personal Context

WILLAPA BAY
### Urban Stream Pesticide Cocktail

<table>
<thead>
<tr>
<th>Herbicides</th>
<th>(Voss 1999)</th>
<th>(Frans 2004)</th>
<th>LC50</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>1.00</td>
<td>0.69</td>
<td>&gt;100,000</td>
</tr>
<tr>
<td>Dicamba</td>
<td>---</td>
<td>0.38</td>
<td>28,000</td>
</tr>
<tr>
<td>Dichlobenil</td>
<td>1.20</td>
<td>0.31</td>
<td>6,260</td>
</tr>
<tr>
<td>MCPA</td>
<td>0.40</td>
<td>0.38</td>
<td>&gt;10,000</td>
</tr>
<tr>
<td>MCPP</td>
<td>0.75</td>
<td>0.52</td>
<td>124,800</td>
</tr>
<tr>
<td>Prometon</td>
<td>0.27</td>
<td>0.19</td>
<td>20,000</td>
</tr>
<tr>
<td>Atrazine</td>
<td>0.02</td>
<td>---</td>
<td>24,000</td>
</tr>
<tr>
<td>Simazine</td>
<td>5.00</td>
<td>0.42</td>
<td>&gt;100,000</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>1.30</td>
<td>0.74</td>
<td>&gt;100,000</td>
</tr>
<tr>
<td>Carbaryl</td>
<td>0.05</td>
<td>0.06</td>
<td>1,950</td>
</tr>
<tr>
<td>Diazinon</td>
<td>0.45</td>
<td>0.58</td>
<td>90</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>0.20</td>
<td>0.12</td>
<td>115</td>
</tr>
<tr>
<td>4-nitrophenol</td>
<td>---</td>
<td>0.46</td>
<td>3,800</td>
</tr>
</tbody>
</table>

Concentrations exceed those associated with agriculture.
“It used to be, everyone was entitled to their own opinion, but not their own facts. But that’s not the case anymore. Facts matter not at all. Perception is everything. Its certainty.”

Stephen Colbert, 26 January 2006
Legacy of Agent Orange
Active Ingredients vs End Products

2 billion lbs AI annually

4.1 billion lbs “inert” ingredients annually

+ Adjuvants and Carriers
Active Ingredients — Formulations — Tank Mixes

A. Percent of Insecticide Products by Number of AIs

Insecticides
80% single AI

B. Percent of Herbicide Products by Number of AIs

Herbicides
65% single AI

C. Number of Label-Recommended Tank Mix Combinations (Binary or Greater)

Herbicides
85% 2+ TM combos

D. Percentage of Label-Recommended Tank Mix Combinations with Three or More Active Ingredients

Herbicides
>50% TM 3+ AI

Active Ingredients — Formulations — Tank Mixes

Insecticides
80% single AI

Herbicides
65% single AI

Herbicides
85% 2+ TM combos

Herbicides
>50% TM 3+ AI
Which Context is Key?

Key to Hazard/Risk Assessment is:

- **Environmental exposure**
  - Operational practices
    - What, where, when?
  - Species and life stages present
    - Which are most vulnerable
      - Life history

- **Example:** Toxicity of aquatic herbicides to amphibians
Overview

• Motivation for this work
  o What’s the problem?

• Pieces of work
  1. Amphibian phenology and habitat use
  2. Effects of triclopyr on metamorphic northern red-legged frogs (*Rana aurora*)
What’s the problem?

Amphibian data are not required in herbicide toxicity testing
What’s the problem?

Existing amphibian data are not relevant to PNW species

≠

Sparling et al. 2010
What’s the problem?

Existing amphibian data are not relevant to PNW life stages.

January/February

March/April
What’s the problem?

Different sensitivities to pesticides exist

(Bridges 2000)

(Harris 2000)
What’s the problem?

Round up ≠

AQUAMASTER

No one studies aquatic formulations
What’s the problem?

We don’t have a complete picture of native amphibian ecology.

[Link to frog-life-cycle.com]
What’s the problem?

We know when and where eggs are laid

Joshua Wallace, FieldHerpFor
What’s the problem?

But when and where do they pop those legs out?
What’s the problem?

Who is at risk of exposure to aquatic weed management?
What to do about the problem?

Two Aquatic Weeds Management Fund Grants - Dept. of Ecology
Pieces of Work

1. Amphibian phenology and habitat use
2. Effects of triclopyr on metamorphic northern red-legged frogs
Young-of-year Oregon spotted frogs are present in late summer.
Northern red-legged frog metamorphs are present in late summer.

Northern Red-legged Frog

Oregon Spotted Frog
Triclopyr & Northern Red-legged Frogs
Triclopyr Tank Mix Methods

Tank mix- labeled rates in 2cm water depth:

- Renovate® 3
  - 47.1 ppm

- Competitor®
  - 41.3 ppm

- Hi-Light®
  - 12.9 ppm
Triclopyr Tank Mix Methods

Control (clean water)

96 h static renewal

47.1 ppm
Triclopyr Tank Mix Methods

Control (clean water)

Tank mix (clean water)

60-d grow out

X 15
Triclopyr Tank Mix Methods

Endpoints:

1. 
2. 
3. 
4. 
5. 
6. 

www.mintees.com/tees/3953 - liver - going - the - extra - bile

Triclopyr Tank Mix Methods
Triclopyr Tank Mix Results

- No treatment-related mortalities
- No gross anomalies in gonad structure
- No treatment-related anomalies in over-all health
Triclopyr Tank Mix Results

Evidence of stress during exposure.

<table>
<thead>
<tr>
<th># Observations</th>
<th>Legs sprawled (n)</th>
<th>Moving (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2 (2)</td>
<td>7 (6)</td>
</tr>
<tr>
<td>Tankmix</td>
<td>22 (12)</td>
<td>12 (8)</td>
</tr>
<tr>
<td>K-S $p$</td>
<td>0.013</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Triclopyr Tank Mix Results

No evidence of color preference

![Graph showing proportion of time on squares for Control and Tank Mix behaviors with no significant preference.](image_url)

- **Proportion of time on squares**
  - CONTROL
  - TANK MIX

**Behavior**

- **Black**

**Statistical Results**

- $P > 0.75$
- $X_c^2 = 0.10$
Triclopyr Tank Mix Results

Time to complete metamorphosis

control

tank mix

Days

10
11
12
13

t-test $P = 0.031$
Triclopyr Tank Mix Results

More evidence of stress during exposure?

Body condition at 96-h

Days

- control
- Tank mix

\[ \Delta P = 0.113 \]
Eventually the controls caught up

Triclopyr Tank Mix Results

Body condition over time

Body condition over time

Metamorphosis complete

30-d post-metamorphosis
Everyone started eating at the same time

First time eating crickets after metamorphosis
Triclopyr Tank Mix Results

Feeding behavior

LMM day 53, $P = 0.199$
Triclopyr Tank Mix Results

No difference in liver condition

$P = 0.942$
Triclopyr Tank Mix Results

No difference in liver histology
Triclopyr Tank Mix Conclusions

- Minimal effects observed
- Stress during exposure – what is real exposure in field?
- Data recording minimal observed effects from herbicide tank mixes are important in conservation work
  - Provides support for managers working with protected or invasive species
  - Informs policy and fills data gaps
Final Thoughts

• Presence of pesticides in surface waters does not necessarily translate to hazard
• Incorporating ecological processes into toxicity testing can improve our ability to inform policy and the public
• “Effects” sell! … but “no effects” can be just as important in supporting habitat management decision-making
• There are risks associated with “no action”
Final Thoughts

• We, as users of herbicides, must do our part to minimize non-target effects
• IPM = Adaptive Management
  ○ Uncertainty drives the process, but does not paralyze it
  • Unfortunately, AM is the exception and not the rule

Associated journal papers are available in the Archives of Environmental Contamination and Toxicology (King) and Environmental Toxicology and Chemistry (King, Yahnke)
Questions?