ES/RP 532
Applied Environmental Toxicology

Lecture 8
Ecotoxicology

Ecorisk Dilemma
- Too many species to protect
- Must accept some adverse effects (practically speaking)
  - Habitat destruction dominates any possible effect that pesticides could have (absent a spill or other intentional misuse)
- Desire to know the likelihood that communities and ecosystems will be affected
  - However, studies are largely based on examining individuals not higher levels of organization

Where is the ECO in Ecotoxicology?
- Tendency to study individuals, yet alone populations and higher levels of organization
  - Thus, most studies are still classical toxicology
- Need to focus on populations, communities, and the ecosystem as a whole
  - Important attributes at higher levels of organization are diversity and functionality
  - However, effects on individuals can have unforeseen consequences to higher levels of organization
  - There could be direct or indirect effects on an organism (and by implication, its population)

Testing at the Individual Level
- Acute toxicity tests
  - Results in determination of LC50 (aquatic or terrestrial dietary or invertebrate in soil) or LD50 (terrestrial forced feeding)
- Chronic toxicity tests
  - Life-cycle exposure
  - Measure reproductive effects
  - Results in determination of NOEC

“New” Era of Ecotox. Testing
- Sublethal effects (in addition to reproductive effects)
  - Predator avoidance
  - Time spent foraging or foraging efficiency
Use of Biomarkers

- Biochemical, physiological, or histological indicators of either exposure to or effects of contaminants (or even natural products) at the suborganismal or organismal level of organization
- Generally measure sublethal effects in live organisms at the time of collection
- Specific and non-specific for contaminants
- May only be indicative of exposure, not an adverse effect
- Must overcome problems related to within population variability and between population variability

Effects at Higher Levels of Organization

- Population Level Effects
- Biomagnification
- Community Level Effects

Acute Toxicity vs. Intrinsic Rate of Increase

- Acute toxicity may predict number of organisms killed, but the population itself may not be affected if survivors are left to breed

Toxicity of Imidacloprid to Neonate & Adult Aphids on Bean Leaves

Copied from Walthall & Stark 1997

Relationship Between Intrinsic Rate of Increase of Aphid Populations on Bean Leaves, Aphid Mortality, and Imidacloprid Concentration

Copyied from Walthall & Stark 1997
Intrinsic Rate of Increase Reaches a Plateau About the Same Time Regardless of Exposure Level, Assuming Enough Neonates Are Still Alive & Healthy

Early Attempts to Measure Biomagnification or Movement of Residues Across Trophic Levels Metcalf Model Ecosystem Studies

**Ecorisk Assessment**
- Deterministic risk assessment
- The new era of probabilistic risk assessment

**Deterministic RA**
- Ratio of the EEC (estimated or expected environmental concentration) to LC50 or NOEC
  - Forms a hazard index
  - Should be less than 1
  - i.e., the EEC should be very low relative to the LC50

**What Is Acceptable Risk?**
The EPA Level of Concern (Warning: Risk Management)

<table>
<thead>
<tr>
<th>Risk Quotient</th>
<th>EEC Tox. Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute High Risk (use LC50)</td>
<td>0.5</td>
</tr>
<tr>
<td>Acute High Risk, restricted use</td>
<td>0.1</td>
</tr>
<tr>
<td>Acute High Risk, endangered spp.</td>
<td>0.05</td>
</tr>
<tr>
<td>Chronic Risk (Use NOEC)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Probabilistic RA**
- Use of species sensitivity distributions
- Use of EEC (measured is preferable) distributions
- Multiply the distributions and determine the overlap
Probabilistic Risk Characterization

- Distribution of Exposure Values
- Distribution of Toxicity Values
- Residues Distribution
- Species Sensitivity Distribution
- Risk

Log Concentration

Joint Probability Curve Used to Aid Risk Management Decisions

Exceedence frequency

Magnitude of effect

More acceptable

Less acceptable

Decreasing risk

Solomon et al. 2000

Probit Transformation of Residue & Species Sensitivity Distributions

Residues

LC5 (µg/L)

LC50 (µg/L)

Marginal of safety with LC50 data

Marginal of safety with EPA LC5 data

Solomon et al. 1996

Atrazine RA

10⁻² 10⁻¹ 10⁻² 10⁻³ 10⁻⁴ 10⁻⁵ 10⁻⁶ 10⁻⁷ 10⁻⁸ 10⁻⁹ 10⁻¹⁰ 10⁻¹¹