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Trophic Response to Multiple Stressors Using Species Sensitivity (SSD) Distribution Models

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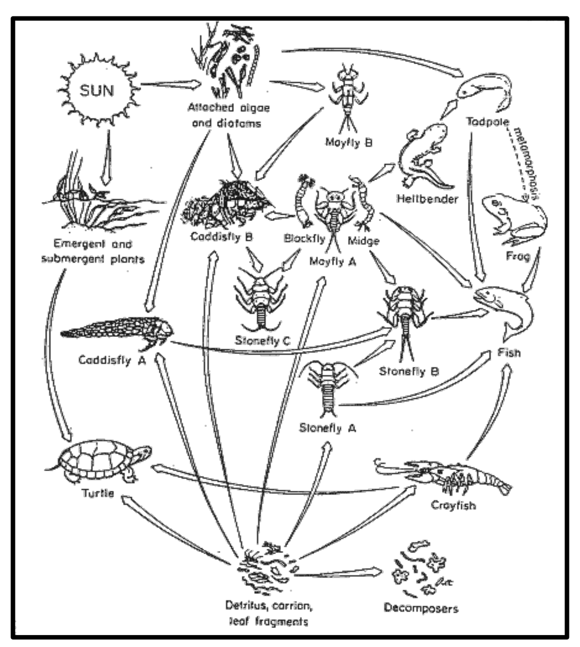
Introduction

For three decades, the species sensitivity distribution (SSD) has been the primary ecotoxicological tool to assess the effects of toxicants on species biodiversity. Despite prolific use by international environmental protection organizations and application in a wide range of ecosystems, there are several problems:

1. The hazardous concentration to protect 95% of a taxonomic group (HC5) is rejecting a portion of species that may have significant ecological roles.
2. Confidence intervals are entirely based on the number of species available with toxicological data and infer a large range of what is considered a "safe" concentration.
3. The regulatory minimum sample size to generate an SSD produces broad confidence intervals.
4. The parameters for data inputs to produce SSDs are not universal.
5. The trophic structure for an endpoint or location is not considered.

In this research we use four taxonomic groups to represent a riparian food web; phytoplankton, zooplankton, macroinvertebrates, and predators. Individual and community SSDs were generated using zinc and copper with at least ten species from each taxonomic group.

Figure 1. Simplified food web of a riparian ecological system. Included are four trophic levels: phytoplankton, zooplankton, macroinvertebrates, and predators.



Methods

Ecotox Data

- All chemicals listed with zinc or copper as the ion were included in generating SSDs.
- Metals were selected based on the availability of toxicity endpoints such as EC50, LC50, and photosynthetic inhibition.
- Species endpoint values were averaged from multiple studies.

Species Sensitivity Distribution

- Each distribution consisted of at least ten laboratory tested species based on the EPA minimum species requirement.
- Data was fitted using log-probit model using the SSD generator provided by CADDIS.
- Community SSD includes all taxa from individual SSDs.

References

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Case Study

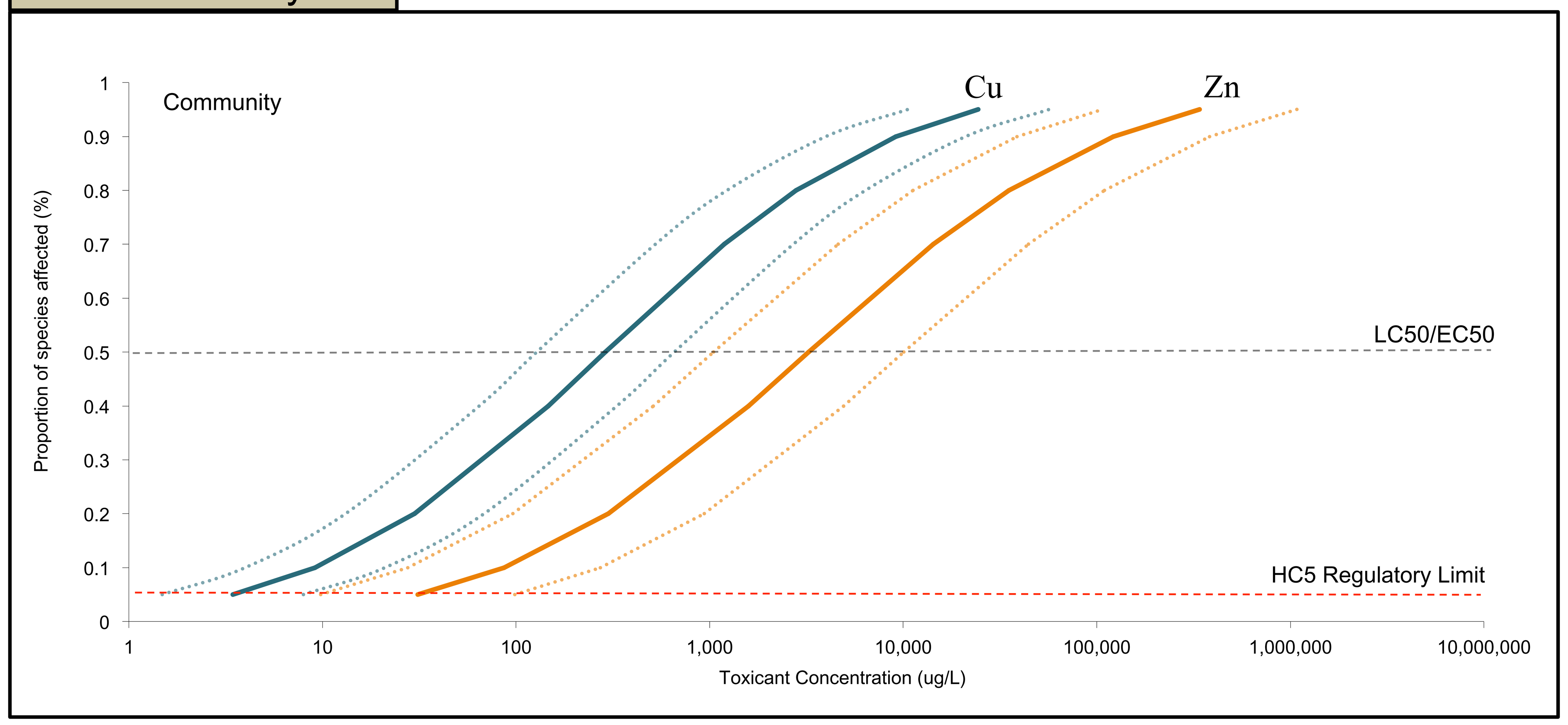

Figure 2. Community Species Sensitivity Distributions for four trophic levels. Each trophic community includes 64 total species for zinc, and 50 total species for copper. Red line indicates the HC5 set by the EPA.

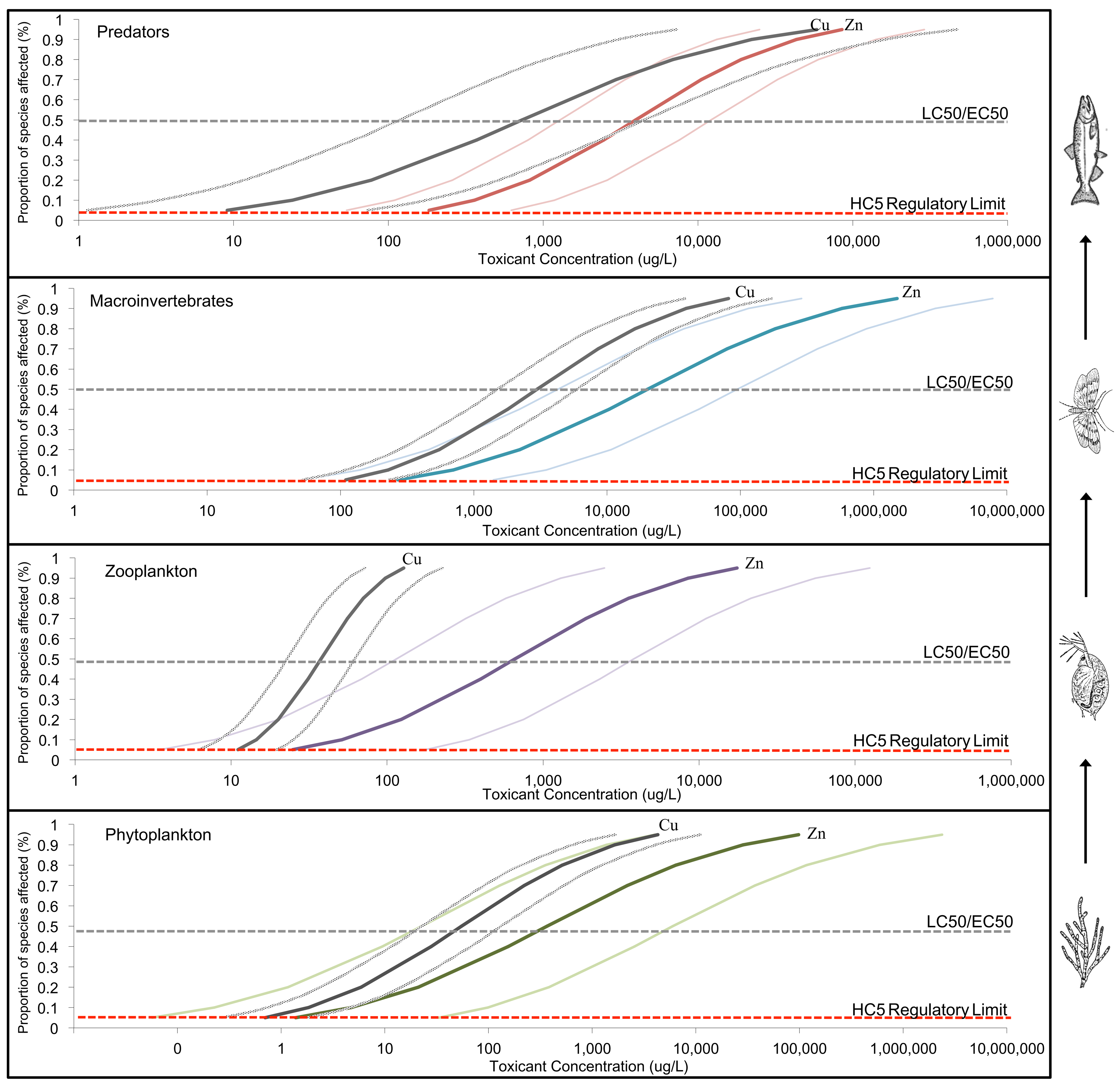

Figure 3. Individual Species Sensitivity distributions for four trophic levels. Each graph is composed of EC50, LC50, and/or IC50 data points for each species. Taxa consist of at least ten species that exhibit aquatic toxicity to zinc or copper. Red line indicates the HC5 set by the EPA.

Table 1. Linking tools with the challenges faced by risk assessors.

Challenge	Tool: ETx	hSSD	Web-ICE	Rationale for AFs	QSARs / weighting	Field / community SSDs
Adequacy of taxonomic 'spread' in data for SSD		Receptor community defined	Better taxonomic representation		Includes specific attributes	
Choice of AF applied to HC5						
Ecological relevance		Receptor community defined	Better taxonomic representation		Better taxonomic representation	
Consistency in estimation of thresholds	Standardized method with good supporting documentation	Modified receptor community		Reduces variability and bias		
SSDs for other stressors	In theory		In theory, could be developed			
Precision of conclusions	CIs around HC5 stabilize		Add species until CIs around HC5 stabilize			

Key: Strong Benefit | Possible Benefit | Uncertain Benefit / Not Relevant

Discussion

Basic communication gaps must be bridged between regulators, stakeholders, and scientists. HC5 values may be underprotective or overprotective depending on the relationships between laboratory tests and field studies. Discontinuation of the use of SSDs is unlikely in the near future due to their prolific use, but there are several considerations to take to decrease uncertainty:

- There are no clear objectives to SSDs rather than to arbitrarily protect *ecosystem health*. Protection goals must be more specific.
- Certain species are more important depending on protection goals.
- A diverse taxonomic range is appropriate when chemicals do not have a specific mode of action.
- Different ecological systems will exhibit a wide range of sensitivities to similar stressors.
- Toxic modes of action should be taken into account to combine similar taxonomic groups.
- Increase the total number of species used to reduce uncertainty.

SSDs rely heavily on prior scientific research from databases such as Ecotox, therefore abundance of laboratory tests for multiple stressors are in demand. These recommendations are likely to foster a better understanding and application of SSDs in the field.