



Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:

Fox, DR

Title:

SSD modeling-It's all about F!

Date:

2016-01-01

Citation:

Fox, D. R. (2016). SSD modeling-It's all about F!. *Integrated Environmental Assessment and Management*, 12 (1), pp.197-198. <https://doi.org/10.1002/ieam.1724>.

Persistent Link:

<https://hdl.handle.net/11343/290778>

Learned Discourse

## SSD MODELING—IT'S ALL ABOUT F!

David R Fox\*†‡

†Environmetrics Australia, Beaumaris, Victoria

‡University of Melbourne, Parkville Victoria, Australia

\*david.fox@environmetrics.net.au

10.1002/ieam.1724</DOI>

The ubiquity and pervasiveness of the species sensitivity distribution (SSD) in ecotoxicology has been well documented (Posthuma et al. 2001 and references therein). Articles have been published on many facets of the SSD modeling approach including, but not limited to

Assumed randomness of the sample of species used to generate the data

Limitations and difficulties due to extremely small sample sizes

Mathematical and/or statistical considerations to do with functional form of the SSD, estimation strategies, and the inferential framework for a derived HC<sub>x</sub>

Although the assumption of randomness has been universally acknowledged (Forbes and Forbes 1993; Van der Hoeven 2004; ECHA 2008) as a necessary and key requirement demanded by statistical theory to ensure the validity of the approach, little or nothing has been done to address the invariable violations of this assumption in practice. Indeed, the advice given in most guideline documents actually guarantees nonrandomness. For example, the revised Australian and New Zealand Water Quality Guidelines recommend using toxicity data from at least 8 species from at least 4 taxonomic groups (Batley et al. 2014). Such purposive sampling is the antithesis of randomness. To further complicate matters, there has been a complete absence of any studies to quantify and describe the impact nonrandom species selection has on the fitted SSD and quantities (such as the HC<sub>x</sub>) subsequently derived from it.

Motivated by this gaping hole in current ecotoxicological practice and my involvement in the preparation of Australia's revised guidelines, which recommended further research be undertaken on this unresolved issue, I took up the challenge. In an article soon to be published in *Environmental Toxicology and Chemistry*, I detail the results of those investigations (Fox 2015). At least initially, I have only investigated what happens to an SSD assumed to follow a log-logistic distribution when the selection of species used to generate the sample data has been biased. Using the very flexible beta distribution to characterize the selection function, it has been shown that the actual distribution arising from nonrandom sampling is  $F$ . This important result is conveniently and compactly summarized as follows.

The actual distribution when an assumed log-logistic SSD having parameters  $(\alpha, \beta)$  is used to describe toxicity data ( $X$ ) that have been selected according to a beta distribution with parameters  $(a, b)$  is a modified  $F$  distribution given by the probability density function (PDF)

$$g_x(x; a, b, \alpha, \beta) = \frac{b\beta}{a\alpha} \left(\frac{x}{\alpha}\right)^{\beta-1} dF\left[\frac{b}{a}\left(\frac{x}{\alpha}\right)^\beta; 2a, 2b\right]$$

where the notation  $dF(x; \nu_1, \nu_2)$  denotes a standard  $F$  distribution having  $\nu_1$  and  $\nu_2$  degrees of freedom. A requirement satisfied by this PDF is that when species selection is truly random (corresponding to the special case of the beta distribution with  $a = b = 1$ ) the distribution is the assumed log-logistic.

A useful outcome of this result is that it is possible to construct a bias correction factor (BCF), which adjusts the  $HC_x$  derived from the fitted SSD to compensate for the nonrandom selection of species data. This BCF is readily computed using intrinsic functions found in Excel. Analysis of the BCF for various selection function shapes suggests that, if the toxicity data are biased toward the more sensitive species as has been suggested (Versteeg et al. 1999), then the common practice of using the lower limit of a confidence interval for the estimated  $HC_x$  may be compensating in the wrong direction. As I note (Fox 2015), this is an issue that requires further research and evaluation as the implications for what has hitherto been understood to be a "protective concentration" may be profound. For example, the SSD methodology is routinely used in Australia to determine a "safe" dilution for effluents from wastewater treatment plants and desalination plants. This, in turn, dictates the depth of an ocean outfall to achieve that dilution. Given that nonrandom species selection for the SSD can result in  $HC_x$  errors of a factor

of 20 or more, it is apparent that either the environmental or monetary cost is potentially significant depending on the direction of this error.

## REFERENCES

- Batley GE, Braga O, Van Dam R, Warne MStJ, Chapman JC, Fox DR, Hickey C, Stauber, JL. 2014. Technical rationale for changes to the method for deriving Australian and New Zealand water quality guideline values for toxicants. Sydney (AU): CSIRO Land and Water Report. 46 p.
- [ECHA] European Chemicals Agency. 2008. Chapter R.10: Characterisation of dose [concentration]-response for environment. In: Guidance on Information Requirements and Chemical Safety Assessment. Helsinki (FI): European Chemicals Agency .
- Forbes TL, Forbes VE. 1993. A critique of the use of distribution-based extrapolation models in ecotoxicology. *Funct Ecol* 7:249–254.
- Fox DR. 2015. Selection bias correction for species sensitivity distribution modelling and hazardous concentration estimation. *Environ Toxicol Chem* DOI: 10.1002/etc.3098
- Posthuma L, Suter GW II, Traas TP. 2001. Species sensitivity distributions in ecotoxicology. Boca Raton (FL): CRC Press. 616 p.
- Van der Hoeven N. 2004. Current issues in statistics and models for ecotoxicological risk assessment. *Acta Biotheoretica* 52:201–217.
- Versteeg DJ, Belanger SE, Carr GJ. 1999. Understanding single species and model ecosystem sensitivity: Data-based comparison. *Environ Toxicol Chem* 18:1329–1346.

Author: Note correction to publication year. Please edit if this is different than the version you are citing.

Author: Note edit to eliminate slashed term. Please re-write if necessary.

Author: Variable edited to comply with journal style for multi-letter equation variables.

Author: Can you provide a report number or URL that links to the document?

Author: Note the inline equation/math has been reset by me to conform to journal style. Please proof for content and confirm or amend.