# The Species Sensitivity Distribution — the de minimis idea, applied to ecosystems

*A standalone analysis (started 2026-06-11), parallel to the Frawley / de minimis dossier in the parent folder. The thesis: the **Species Sensitivity Distribution (SSD)** — the dominant method for setting environmental "safe" concentrations for pollutants — is the ecological branch of the same move our main essay anatomizes. It takes a database of toxicity numbers, fits a distribution, reads a threshold off a chosen low percentile, multiplies by a factor, and calls everything below it safe. It is the de minimis principle wearing a lab coat, drawn over species instead of chemicals.*

**Grading. [2]** established in the peer-reviewed / agency literature (cited) · **[synthesis]** our analytical connection · **[open]** to verify or develop. No invented locators. Cross-references to the parent dossier: `../10_DE_MINIMIS_LEGAL_LINEAGE.md`, `../09_IBT_FRAWLEY_OVERLAP.md`, and the essay drafts in `../reckoningscience/`.

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## 1. What an SSD is

A Species Sensitivity Distribution is a statistical curve fitted to the sensitivities of many species to a single chemical. For each species you have a toxicity value — a no-effect concentration (NOEC) or an effect concentration (EC50/LC50). Plot those values, fit a distribution (classically log-normal), and you have a curve that runs from the most sensitive species to the most tolerant. **[2]** (Posthuma, Suter & Traas, *Species Sensitivity Distributions in Ecotoxicology*, 2002).

From that curve you read a single number. The convention is the **HC5 — the Hazardous Concentration for 5% of species — the fifth percentile of the distribution.** A concentration at the HC5 is, by the model, harmful to 5% of species and tolerable to the other 95%. The regulatory choice is stated plainly in the field's own words: "to protect 95% of species and, thereby, to accept an adverse effect on 5%." **[2]** (Frontiers in Environmental Science, 2020; Posthuma et al. 2002).

The HC5 is then divided by an **assessment factor (typically 1–5)** to give the **Predicted No-Effect Concentration (PNEC)** — the number below which an ecosystem is declared "sufficiently protected." **[2]** (the HC5/AF→PNEC step is standard in REACH and the EU Technical Guidance; Predicted No-Effect Concentration is the regulatory output). So the pipeline is:

> toxicity data per species → fit a distribution → read the **5th percentile (HC5)** → ÷ assessment factor → **PNEC** = "safe" concentration.

## 2. Where it came from

The SSD did not fall from the sky; it is a refinement of the **safety-factor tradition** — the same tradition that produced the human "factor of 100" our first essay traced. Before SSDs, ecological thresholds were set the crude way: take the lowest toxicity value you have and divide by an **assessment factor** (10, 100, 1000) to cover the species you did not test. **[2]** SSD was sold as the rigorous, "data-driven" replacement for that guesswork — exactly the pitch the Threshold of Toxicological Concern made against the human safety factor.

Key steps in the lineage **[2]**:

- **Kooijman (1987)** — the seminal paper, titled, tellingly, *"A safety factor for LC50 values allowing for differences in sensitivity among species."* He modeled species sensitivity as a distribution and asked how far below the data you must go to protect the community. The method is born as a *better safety factor.*
- **Van Straalen & Denneman (1989)** — turned it into policy: choose a *protection goal* expressed as a percentage of species to protect, and derive the concentration that meets it. The 95%/5% convention enters here.
- **United States, in parallel — Stephan et al., EPA (1985)**, *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (local snapshot: `sources/EPA_1985_Guidelines_...pdf`). The EPA set its criterion at the **fifth percentile** of Genus Mean Acute Values — the "Final Acute Value." The U.S. and Europe converged independently on the same cutoff: the **5th percentile. [2]**
- **Aldenberg & Slob (1993)** — put confidence limits on the HC5, making it look like a measurement.
- **Posthuma, Suter & Traas (2002)** — the canonical textbook; **Posthuma et al. (2019)** — SSDs for **12,386 chemicals**, a database of thresholds on the scale of an industry.

It is now load-bearing law. **REACH** uses the PNEC; the **EU Water Framework Directive** uses Environmental Quality Standards derived the same way; the **US EPA aquatic life criteria** rest on the 1985 5th-percentile method; Australia/New Zealand and others follow. Both REACH and the WFD operate, in the field's phrase, via "the protective benchmark no-effect concept … below which ecosystems are considered 'sufficiently protected.'" **[2]**

## 3. The same machine as de minimis

Set the SSD beside the human-health threshold our main essay follows, and they are the same device built on different axes. **[synthesis]**

| | **TTC (human de minimis endpoint)** | **SSD (ecological threshold)** |
|---|---|---|
| Database | NOAELs across **chemicals** (within a Cramer structural class) | sensitivities across **species** (for one chemical) |
| Fit | distribution of NOAELs | distribution of sensitivities |

| | TTC (human de minimis endpoint) | SSD (ecological threshold) |
|---|---|---|
| Read-off | **5th percentile** of the NOAEL distribution | **5th percentile** = **HC5** |
| Factor | × 1/100 safety factor | ÷ assessment factor (1–5) |
| Output | TTC (µg/day) below which a chemical needs no testing | PNEC / EQS below which a discharge is "safe" |
| Claim | "toxicologically insignificant" | "sufficiently protected" |

The match is not loose. **Munro et al. (1996)** built the TTC by taking **the 5th percentile of the NOAEL distribution** for each Cramer class (613 chemicals, 2,941 NOAELs) and applying a **100-fold** safety factor — yielding 1800 / 540 / 90 µg/person/day for Cramer classes I/II/III. **[2]** The SSD takes **the 5th percentile of the sensitivity distribution** and applies an assessment factor. *Same statistic, same arbitrary 5%, same bolted-on factor — one drawn over chemicals, the other over species.* **[synthesis]**

And the two have already been fused. The **"ecological Threshold of Toxicological Concern" (eco-TTC)** borrows the TTC name outright for ecology: Rizzi, Villa, Cuzzeri & Finizio (2021) derive it by taking **"the fifth percentile [HC5] of available HC5 values within pesticide classes," then dividing by an assessment factor of 5. [2]** That is a fifth percentile of fifth percentiles — the TTC's cross-chemical distribution logic stacked on top of the SSD's cross-species one. The branches of the lineage are now grafting back together.

So the genealogy runs:

> the human **factor of 100** (Lehman & Fitzhugh) → Frawley's **"ignorance factor… overly conservative"** and his **0.1 ppm** de minimis → NAS *Toxicologically Insignificant Levels* (1969) → the **Threshold of Regulation** (21 CFR 170.39, 1995) → the **TTC** (Munro; EFSA 2019)
>
> with an **environmental branch** off the same safety-factor root: assessment factors → **Kooijman 1987 / Van Straalen & Denneman 1989 / EPA 1985** → the **SSD / HC5 / PNEC** → the **eco-TTC**.

Both branches do the one move our essay is about: convert an admitted ignorance — we cannot test every chemical on every human, or every pollutant on every species — into a number that licenses not finding out.

## 4. Where it breaks — the same seams as de minimis

The critique we make of de minimis transfers, point for point, and in some places bites harder. **[synthesis]**, with the literature where it exists **[2]**.

- **The 5% is a value judgment dressed as a calculation.** Nothing in the data says protect 95% rather than 99% or 99.9%. "Accept an adverse effect on 5%" of species is a policy choice — who is sacrificed, and how many — wearing the costume of a percentile. It is the round number standing in for a

decision no one wants to own, exactly like Frawley's 0.1 ppm and the factor of 100. The field concedes the 5% is conventional, not derived.

- **Protecting 95% of species is not protecting the ecosystem.** The HC5 treats species as interchangeable units. It is blind to *which* 5% is lost — a keystone predator, a foundation species, a pollinator — and to the interactions, food-web effects, and functions that a community is more than the sum of. A number that is "protective" of species can still let an ecosystem fall over.
- **The database is selection-biased, the way Frawley's was.** An SSD is built from the species that can be cultured and tested in a lab — daphnids, a few fish, an alga — not from the community actually exposed. The same survivorship logic Summerson named in 1968 applies: Frawley's library held only compounds non-toxic enough to survive a two-year study; an SSD holds only species hardy enough to be standard test organisms. The most sensitive members of a real community may never enter the curve.
- **The wrong-unit problem returns.** The SSD assumes a threshold concentration exists below which there is no effect. For stressors where that is false — endocrine disruptors with low-dose and non-monotonic responses, bioaccumulative and persistent chemicals whose harm is a function of time not concentration, and chemical *mixtures* (real water carries hundreds at once) — the no-effect concentration is not a property the stressor has. This is the ecological twin of the genotoxic-carcinogen category error in `../09_IBT_FRAWLEY_OVERLAP.md`: the threshold names a quantity that, for the cases that matter most, does not exist.
- **Lab to field.** Single-species, single-chemical, short-term lab endpoints are extrapolated to multi-species communities under chronic, mixed, fluctuating real exposure. The assessment factor (1–5 on the HC5) is the modern "ignorance factor" papering the gap — smaller than Lehman's 100, and carrying the same content: a guess about how much we do not know.
- **Summerson's objection, transposed.** "No knowledge of harm is not knowledge of no harm." An HC5 fitted to a dozen tested species is silent about the untested thousands, and a PNEC certifies "no effect" precisely where no one looked.

## 5. In fairness — where SSD is the better instrument

The balanced reading, the same we owe Frawley, is owed here too. **[synthesis]**

- SSD is **honest about its sacrifice** in a way de minimis is not. "Accept harm to 5% of species" states the trade-off out loud; "toxicologically insignificant" hides it. A framework that names its body count is more defensible than one that denies there is one.
- It uses **real toxicity data**, not the pure structural analogy the TTC leans on for untested chemicals.
- It is **probabilistic and improvable** — Bayesian and nonparametric versions, confidence intervals, larger databases — where Frawley's single cut-off was a flat line.
- And the underlying instinct is, again, not unreasonable: you cannot test every pollutant on every species, and a transparent, data-based threshold beats an

official's hunch.

None of that touches the core. The honesty is about the *cutoff*; the blind spot is in the *premise* — that a distribution over the species you happened to test, read at a percentile you happened to choose, bounds the harm to a community you did not test, from a stressor that may not have a threshold at all.

## 6. Verdict

The Species Sensitivity Distribution is the numerology of toxicology carried into the river. It answers a question no one can answer — how much of this chemical can the living world absorb without damage — by drawing a curve through the handful of creatures we know how to poison on a bench, reading a number off the lower tail, dividing by a factor, and certifying everything beneath it as no effect. It is more sophisticated than Frawley's 0.1 ppm and more honest than his "insignificance," and it is the same act: a round number standing in for knowledge we do not have, used to permit exposure up to a line and to declare the line safe. The de minimis idea did not stay in the food-packaging file. It went into the water.

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## Sources

*(Peer-reviewed and agency literature; full bibliographic capture is a follow-up. The one local snapshot is the EPA 1985 primary.)*


- **Kooijman, S.A.L.M. (1987).** "A safety factor for LC50 values allowing for differences in sensitivity among species." *Water Research* 21(3):269–276. — SSD origin. **[2]**
- **Van Straalen, N.M. & Denneman, C.A.J. (1989).** "Ecotoxicological evaluation of soil quality criteria." *Ecotoxicol. Environ. Saf.* 18(3):241–251. — the protection-goal / % of species formulation. **[2]**
- **Stephan, C.E., Mount, D.I., Hansen, D.J., Gentile, J.H., Chapman, G.A., Brungs, W.A. — US EPA (1985).** *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses.* — the 5th-percentile "Final Acute Value." **Local:** `sources/EPA_1985_Guidelines_...pdf`. **[2]**
- **Aldenberg, T. & Slob, W. (1993).** "Confidence limits for hazardous concentrations based on logistically distributed NOEC toxicity data." *Ecotoxicol. Environ. Saf.* 25(1):48–63. **[2]**
- **Posthuma, L., Suter, G.W. II & Traas, T.P. (eds.) (2002).** *Species Sensitivity Distributions in Ecotoxicology.* Lewis. — canonical reference. **[2]**
- **Posthuma, L., et al. (2019).** "Species sensitivity distributions for use in environmental protection, assessment, and management of aquatic ecosystems for 12 386 chemicals." *Environ. Toxicol. Chem.* 38(4). PMC6907411. **[2]**
- **Munro, I.C., Ford, R.A., Kennepohl, E. & Sprenger, J.G. (1996).** TTC database of 613 chemicals / 2,941 NOAELs; 5th-percentile NOAEL + 100× → TTC. (See EFSA 2019, EFSA Journal 17(6):5708; FPF TTC dossier 2024.) **[2]**

- **Cramer, G.M., Ford, R.A. & Hall, R.L. (1978).** the decision tree / Cramer classes. **[2]**
- **Rizzi, C., Villa, S., Cuzzeri, C. & Finizio, A. (2021).** "Use of the Species Sensitivity Distribution Approach to Derive Ecological Threshold of Toxicological Concern (eco-TTC) for Pesticides." *Environ. Toxicol. Chem.*; PMC8623465. — eco-TTC = 5th percentile of HC5 values ÷ AF 5. **[2]**
- **Predicted No-Effect Concentration** — REACH/WFD regulatory output; HC5 ÷ assessment factor. (EU Technical Guidance; ECHA.) **[2]**

## Open / next

- **[open]** Pull and snapshot the primary abstracts (Kooijman 1987; Van Straalen & Denneman 1989; the eco-TTC) and capture verbatim the "protect 95% / accept 5%" and "5th percentile of HC5" wordings into `ssd/sources/`.
- **[open]** Trace whether the ecotox and human-tox threshold communities cross-cite explicitly — does anyone name SSD/PNEC and TTC as one family? (eco-TTC is the closest published bridge.) A clean cross-citation would upgrade the lineage from **[synthesis]** to documented.
- **[open]** The strongest critique literature on SSD (the "5% is arbitrary," mixtures, and field-validation critiques) — assemble for the critical section.
- **[idea]** If this ever becomes its own "Reckoning Science" piece: the structural rhyme with the main essay (Summerson's survivorship point ↔ the tested-species bias; the genotoxic category error ↔ non-threshold stressors and mixtures) is the spine.