

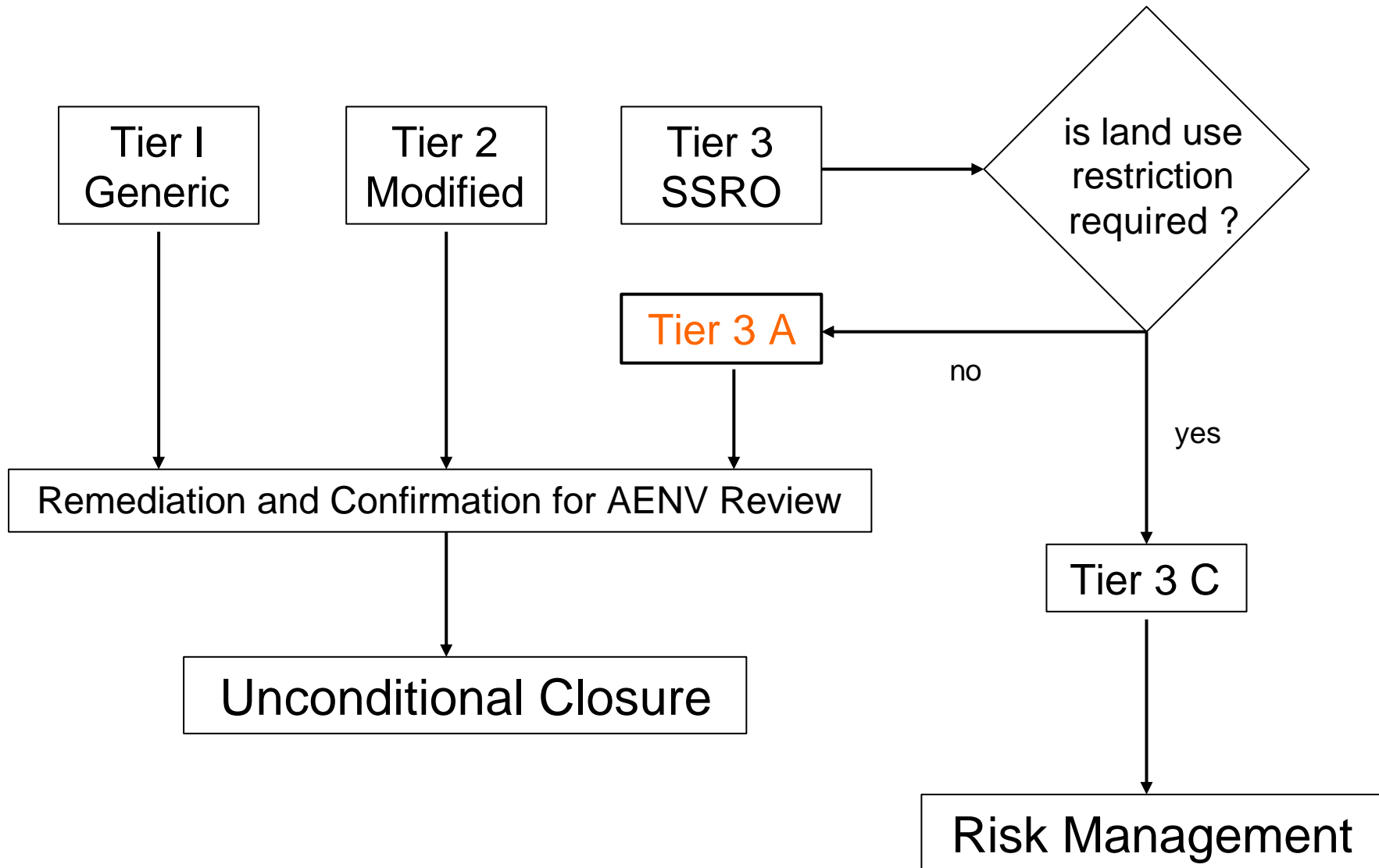
Development of Site-Specific Remedial Objectives (SSROs) for Weathered Petroleum Hydrocarbon in Peat Soils

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Regulatory Framework



Candidate Sites for Tier 3A



- ❑ Natural land use settings in which aromatics and F1 are not the primary contaminants of concern
- ❑ Generally large sites with extensive shallow impacts
- ❑ Continued remedial activity no longer effective

Applicable Pathways

Terrestrial Settings Only



Parameter	<i>de minimis</i> Pathway	Remedial Objective (mg/kg)
Benzene	Groundwater Potability	0.13
Toluene	Groundwater Potability	1.60
Ethyl benzene	Groundwater Potability	0.36
Total xylene	Groundwater Potability	49
CCME F1	Eco-Soil Contact	SSRO or Tier 1
CCME F2	Eco-Soil Contact	SSRO
CCME F3	Eco-Soil Contact	SSRO
CCME F4	Eco-Soil Contact	SSRO

Applicable Pathways

Terrestrial Settings with Water Bodies



Parameter	<i>de minimis</i> Pathway	Remedial Objective (mg/kg)
Benzene	Groundwater Potability	0.13
Toluene	Groundwater Aquatic Life	0.16
Ethyl benzene	Groundwater Potability	0.36
Total xylene	Groundwater Potability	49
CCME F1	Eco-Soil Contact	SSRO or Tier 1
CCME F2	Groundwater Aquatic Life	230
CCME F3	Eco-Soil Contact	SSRO
CCME F4	Eco-Soil Contact	SSRO

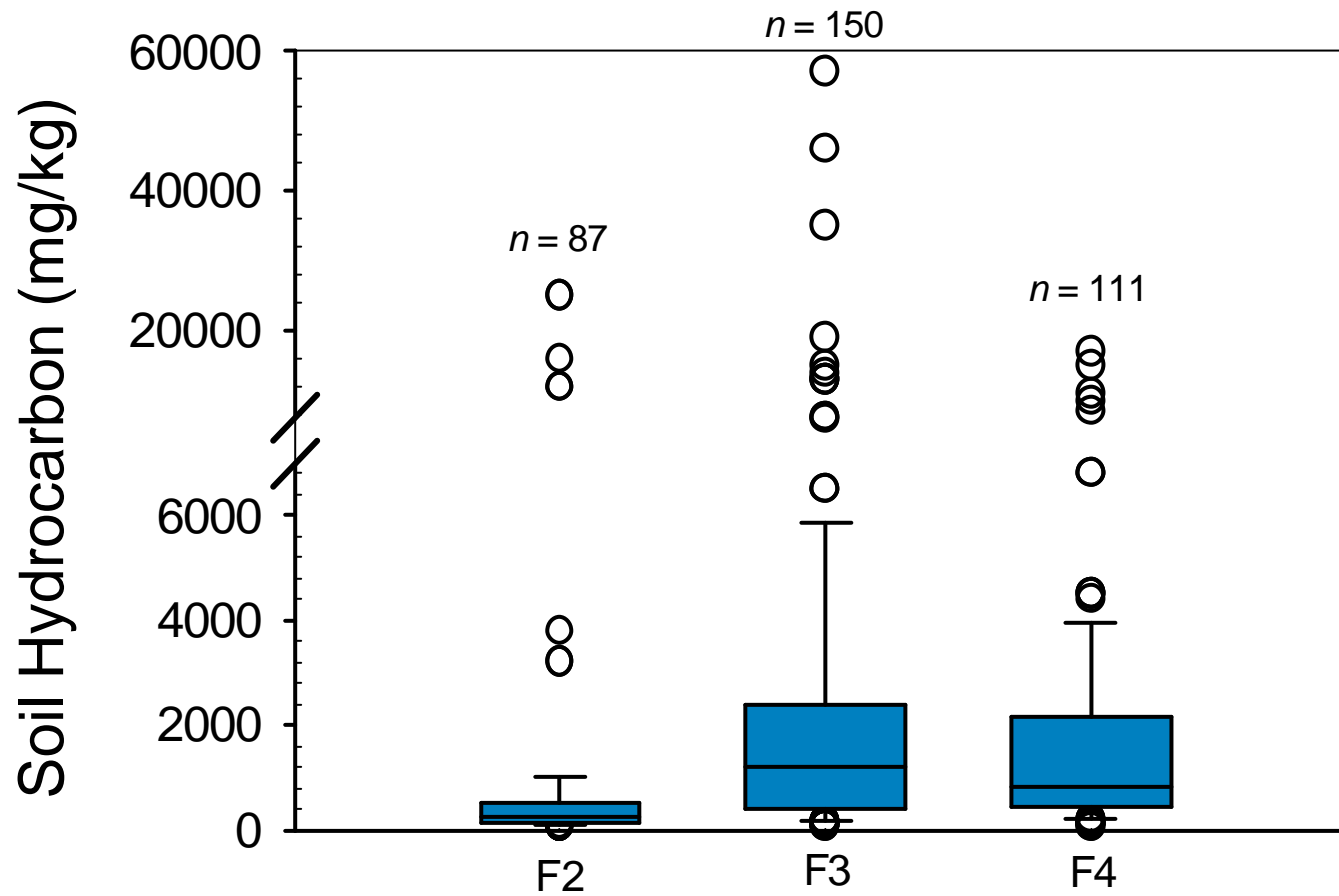
Site Characterization



- ❑ Light crude release to boreal peat land environment more than 10 years ago
- ❑ Following immediate spill recovery, straw and fertilizer was applied and land farming was periodically conducted
- ❑ 2002 Delineation/SSRO Development
 - ❑ **grid pattern sampling with over 120 samples collected**
 - ❑ **discrete sampling at surface, 0.5m and 1.0m depths**
 - ❑ **limited PAH analysis detected lower molecular weight naphthalene, methylnaphthalene and phenanthrene**
 - ❑ **no trace metals detected above applicable guidelines**
 - ❑ **organic carbon content ranged from 19 – 21 % in peat material**

Soil Hydrocarbons

Lognormal Distribution



Residual Candidate Soils

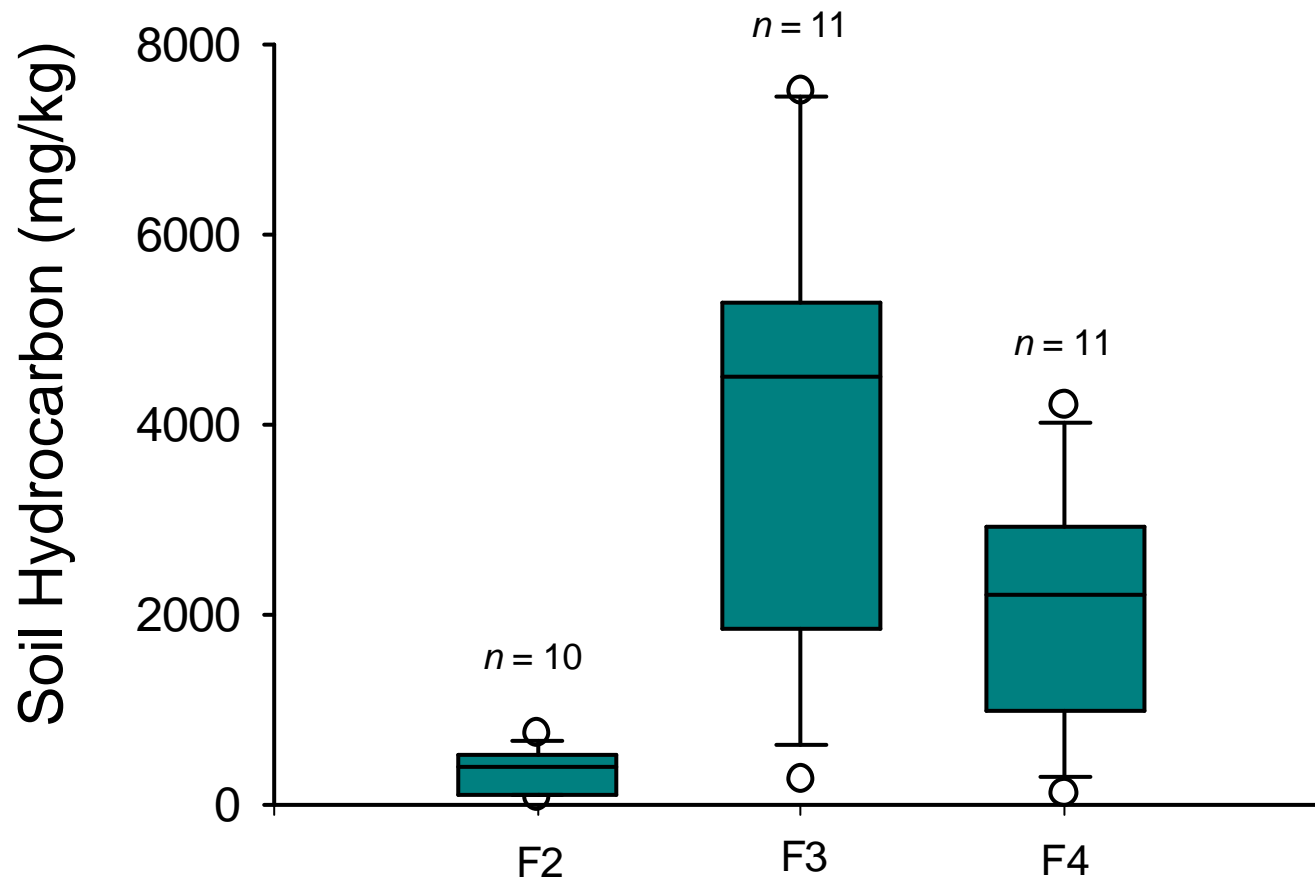


Bulk samples for toxicological testing

- ❑ Re-mobilize for collection of bulk 4 L samples for toxicity testing
 - ❑ field control soils
 - ❑ wide areal representation
 - ❑ capture expected residual hydrocarbon gradient

- ❑ Target numerical criteria for bulk samples
 - ❑ fail *de minimis* F2, F3, F4 eco-soil contact criteria
 - ❑ no detectable F1 or BTEX (i.e. no hot spot soils)

Soil Hydrocarbon Range Toxicological Samples



Selection of Test Species



- ❑ CCME 1996 minimum data requirements
 - ❑ minimum of 10 data point, including ...
 - ❑ 2 soil invertebrates
 - ❑ 2 crop/plants
 - ❑ both lethal and sub-lethal effects evaluated

- ❑ Program included standard species used in CCME 2000 CWS PHC and site-specific trees
 - ❑ black spruce and tamarack seed emergence and root elongation
 - ❑ lettuce seed emergence and root elongation
 - ❑ acute earthworm growth and mortality
 - ❑ sub-acute springtail survival and reproduction

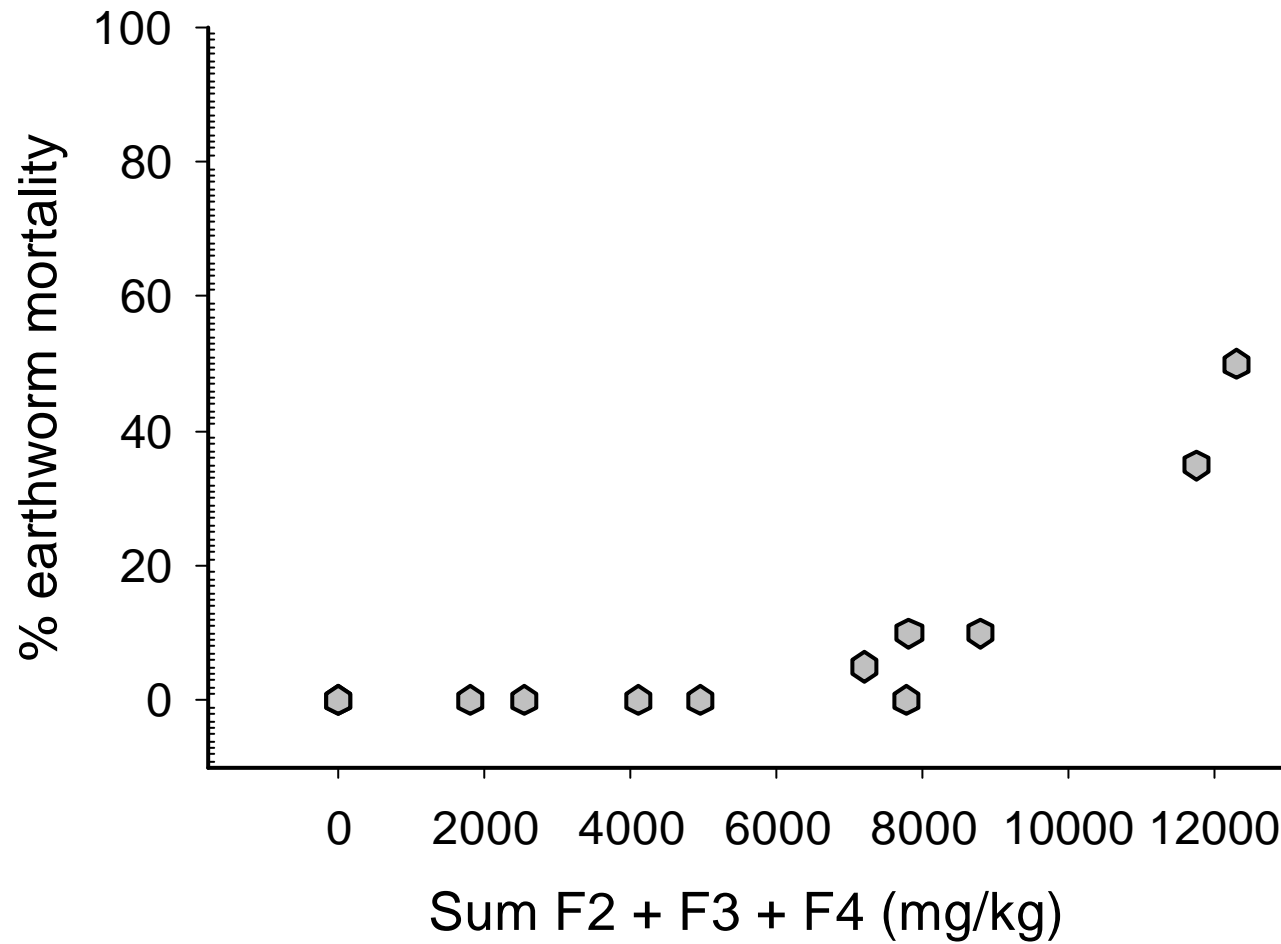
Selection of SSRO Parameter



- ❑ Separate SSRO's for each CCME fraction ?
- ❑ Gravimetric heavy hydrocarbon (GHH) SSRO ?
- ❑ Cumulative CCME F2 + F3 + F4 based SSRO ?
- ❑ Qualitative evaluation of cumulative data suggested F2+F3+F4 explained the toxicological responses better than all other parameters.

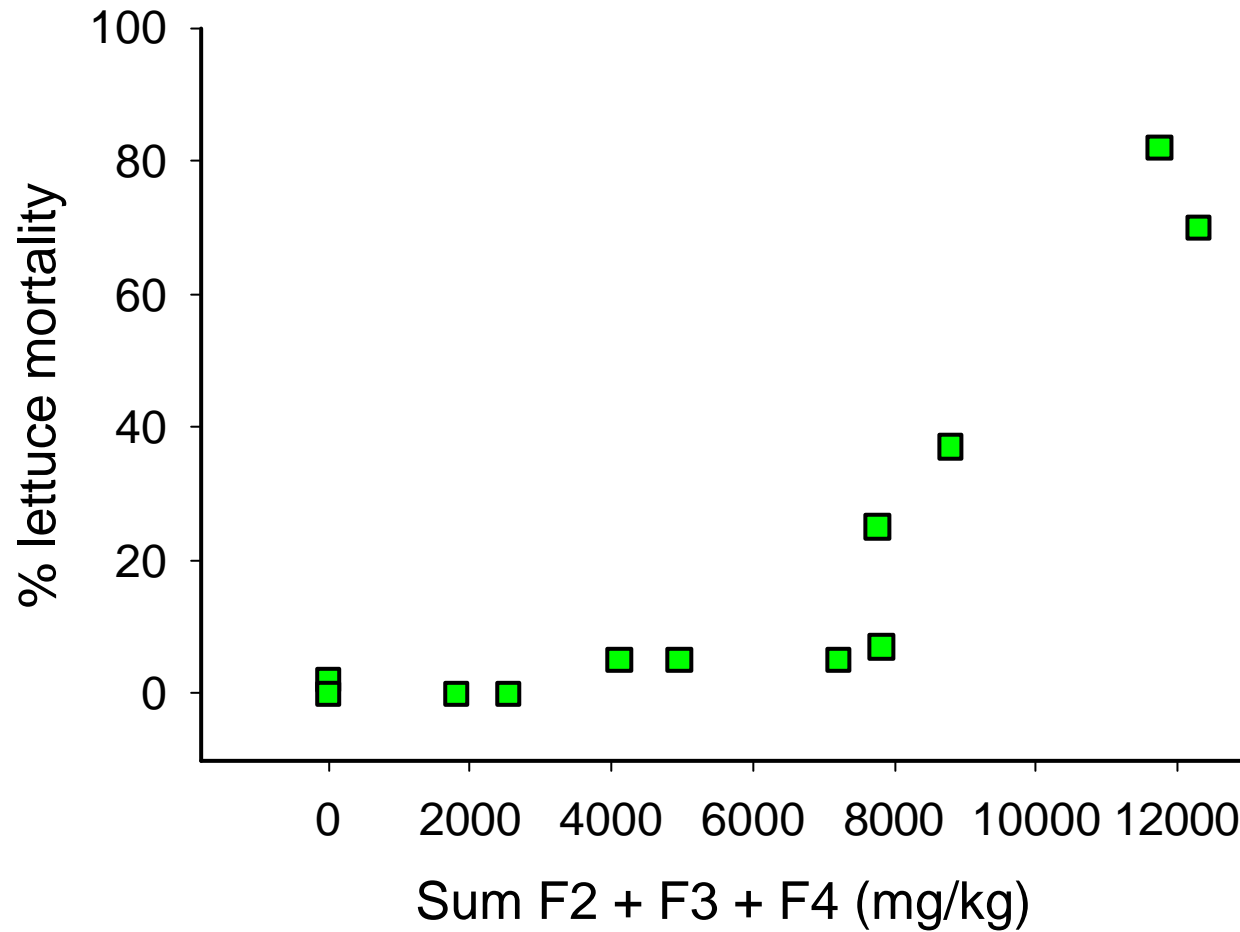
Dose – Response

Earthworm Mortality



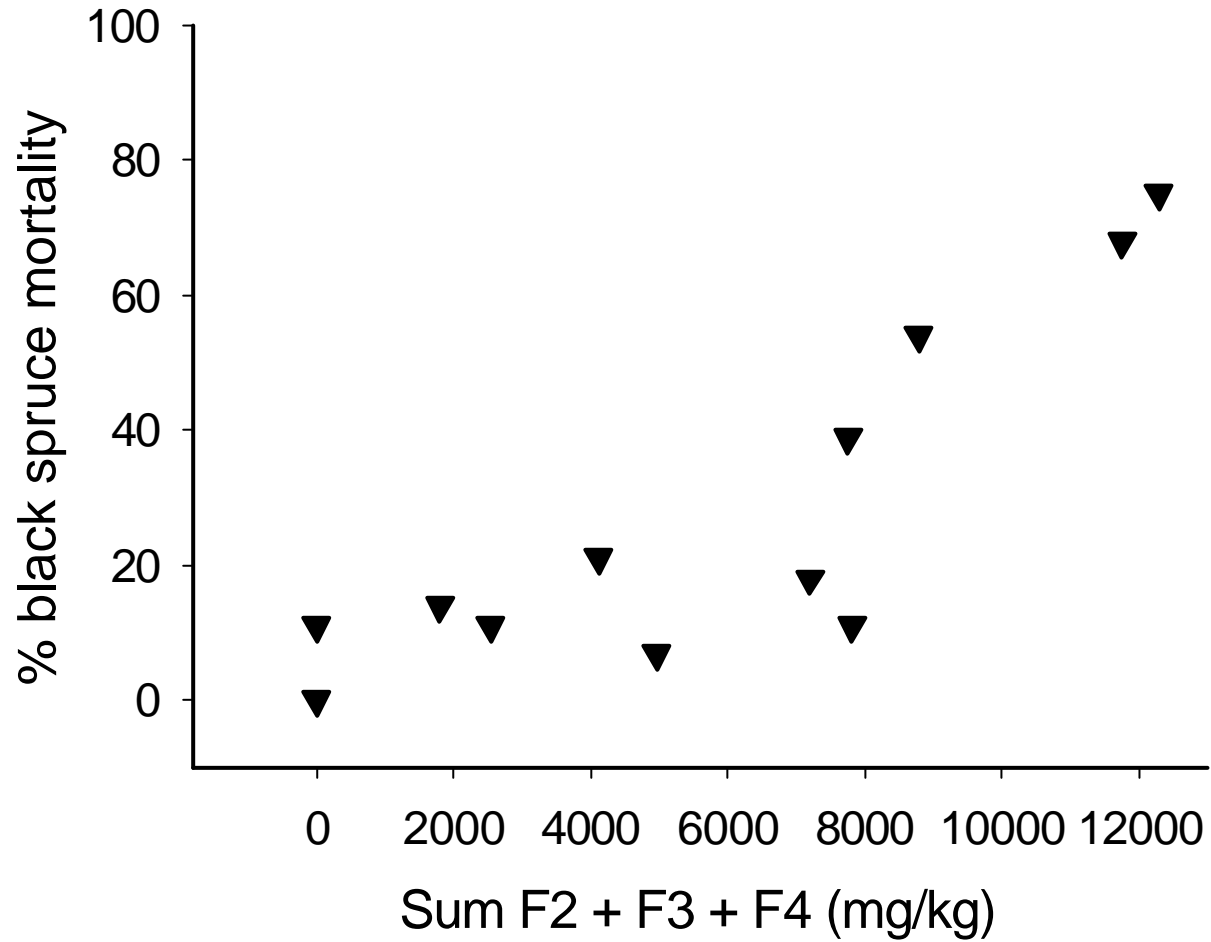
Dose - Response

Lettuce Emergence



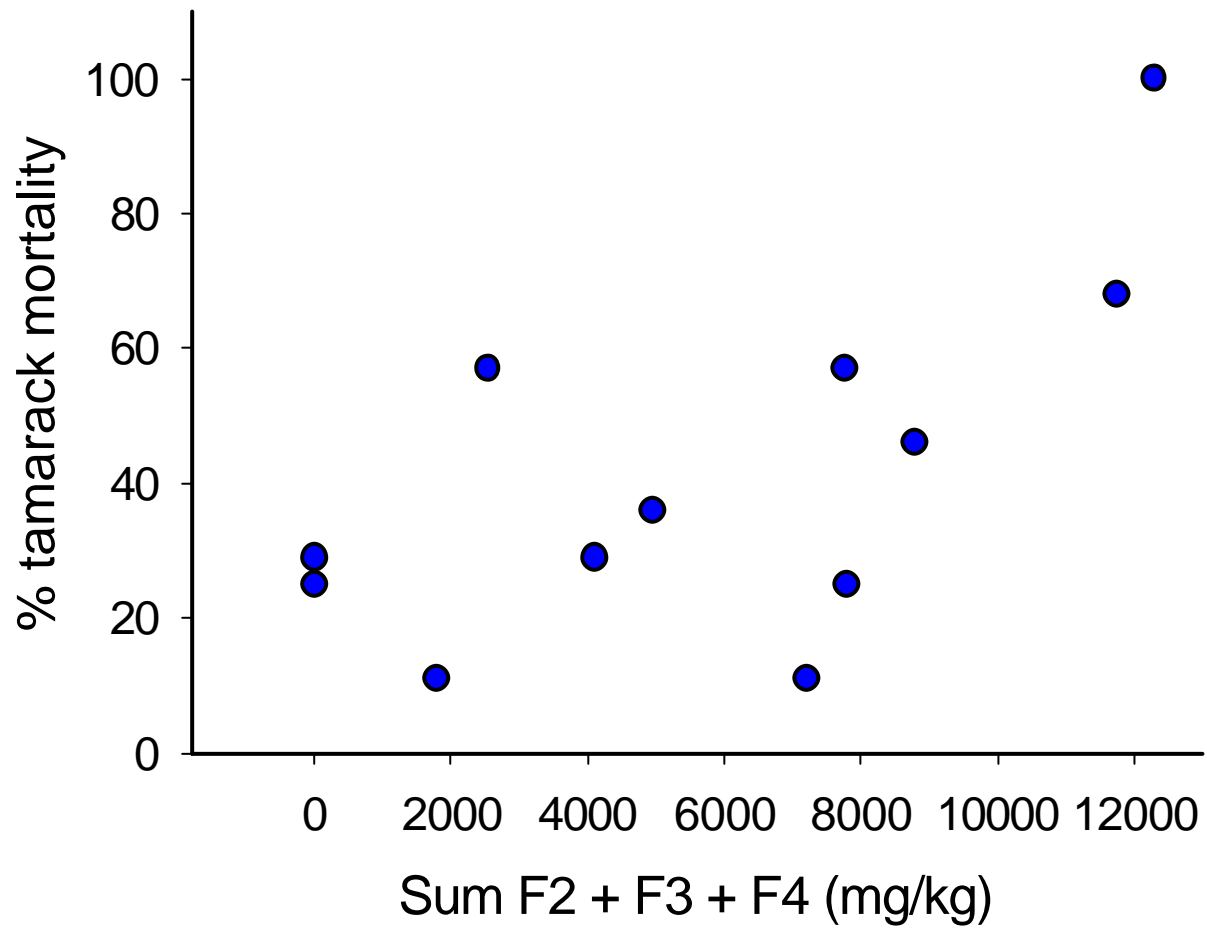
Dose - Response

Black Spruce Emergence



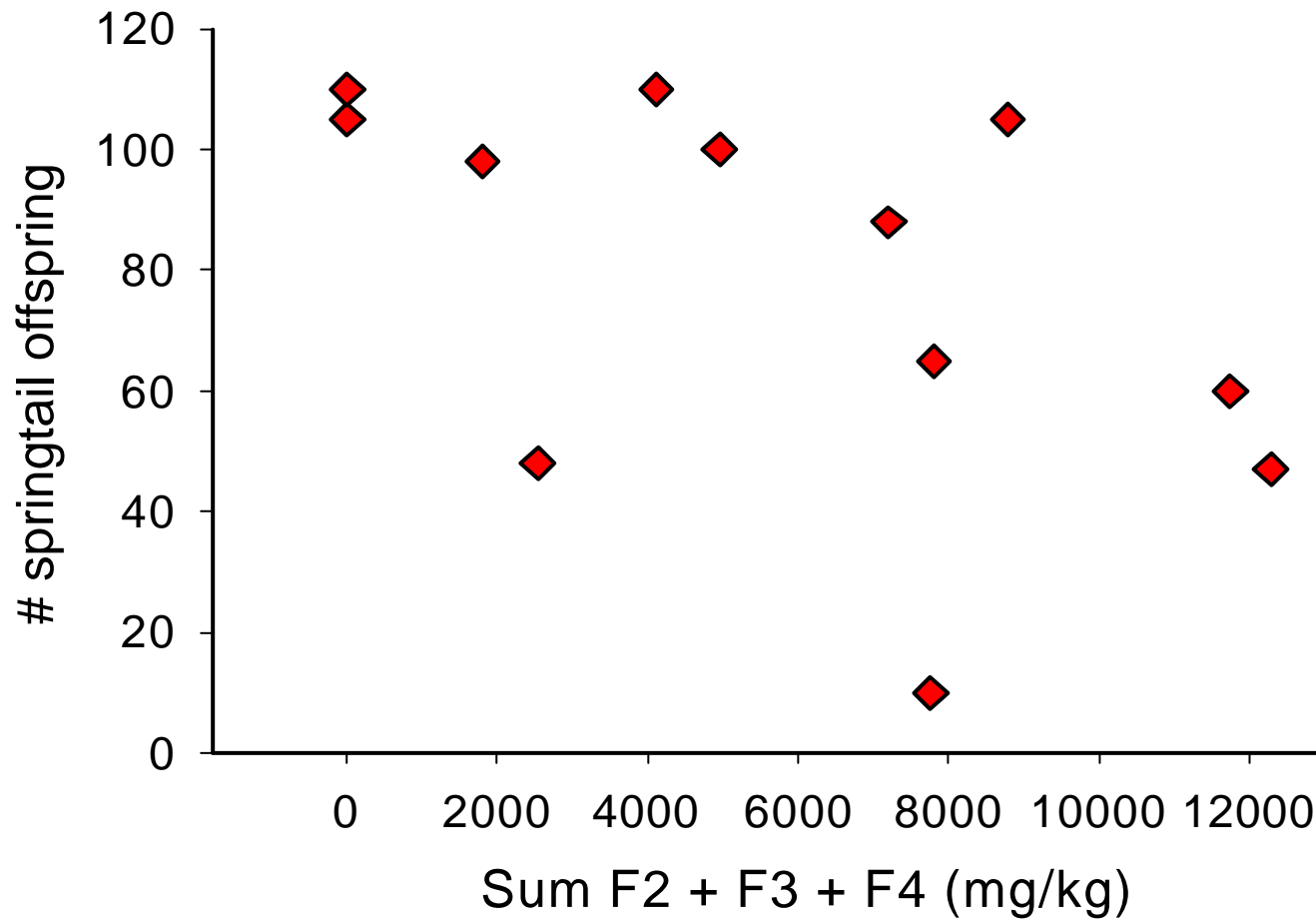
Dose - Response

Tamarack



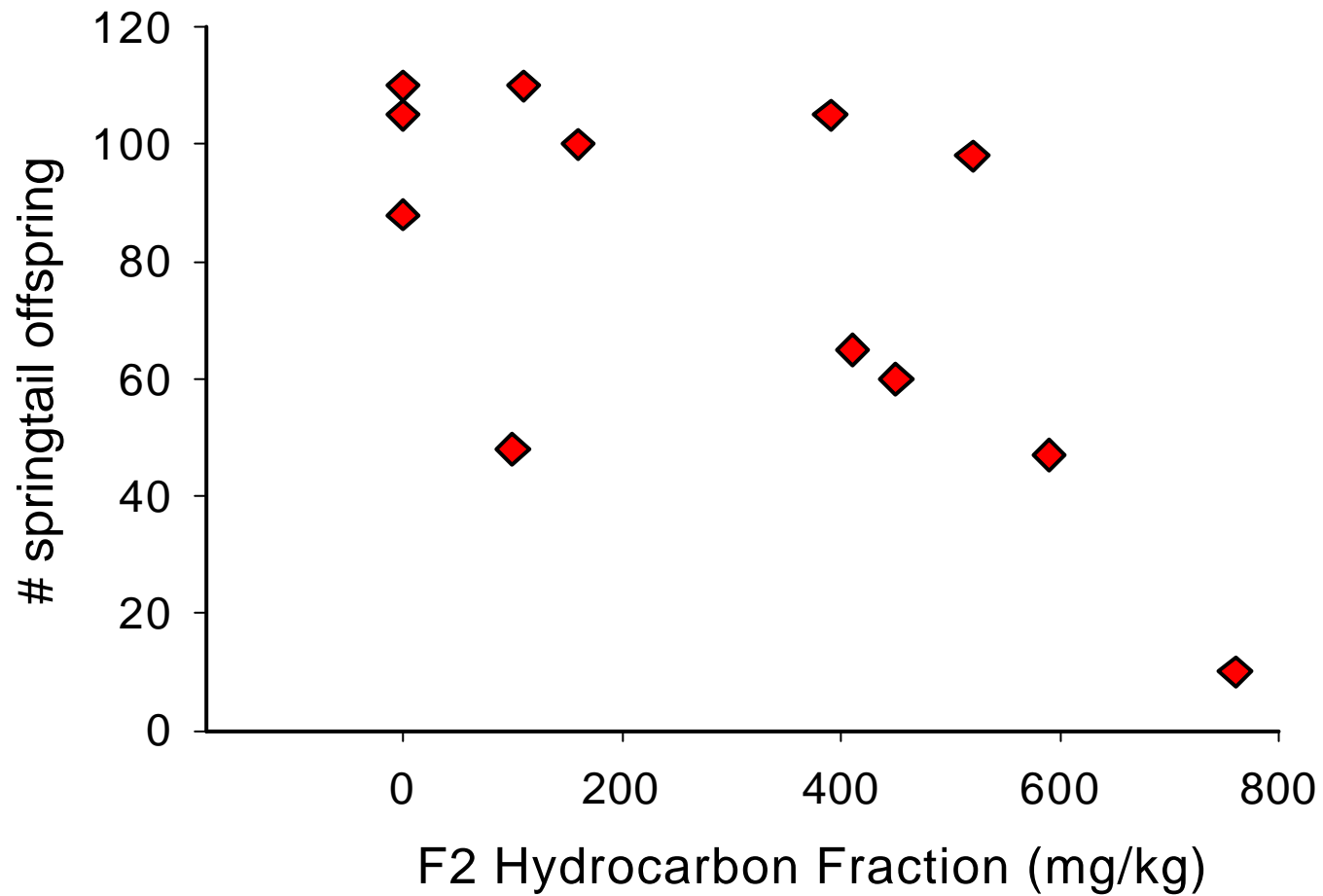
Dose – Response

Springtail Reproduction



Dose – Response

Springtail Reproduction and F2



Laboratory Bioassays

- ❑ Undiluted tests
 - ❑ number of survivors, offspring, emergent seeds or growth (root length or wet weight)
 - ❑ percentage response relative to artificial control response (e.g. 50 % less seeds emerged compared to controls)

- ❑ Laboratory multiple range testing
 - ❑ dilution with artificial soil (25%; 50%; 75%)
 - ❑ earthworms, springtail and lettuce only
 - ❑ tree species not included

Data Analysis

Generation of Endpoints

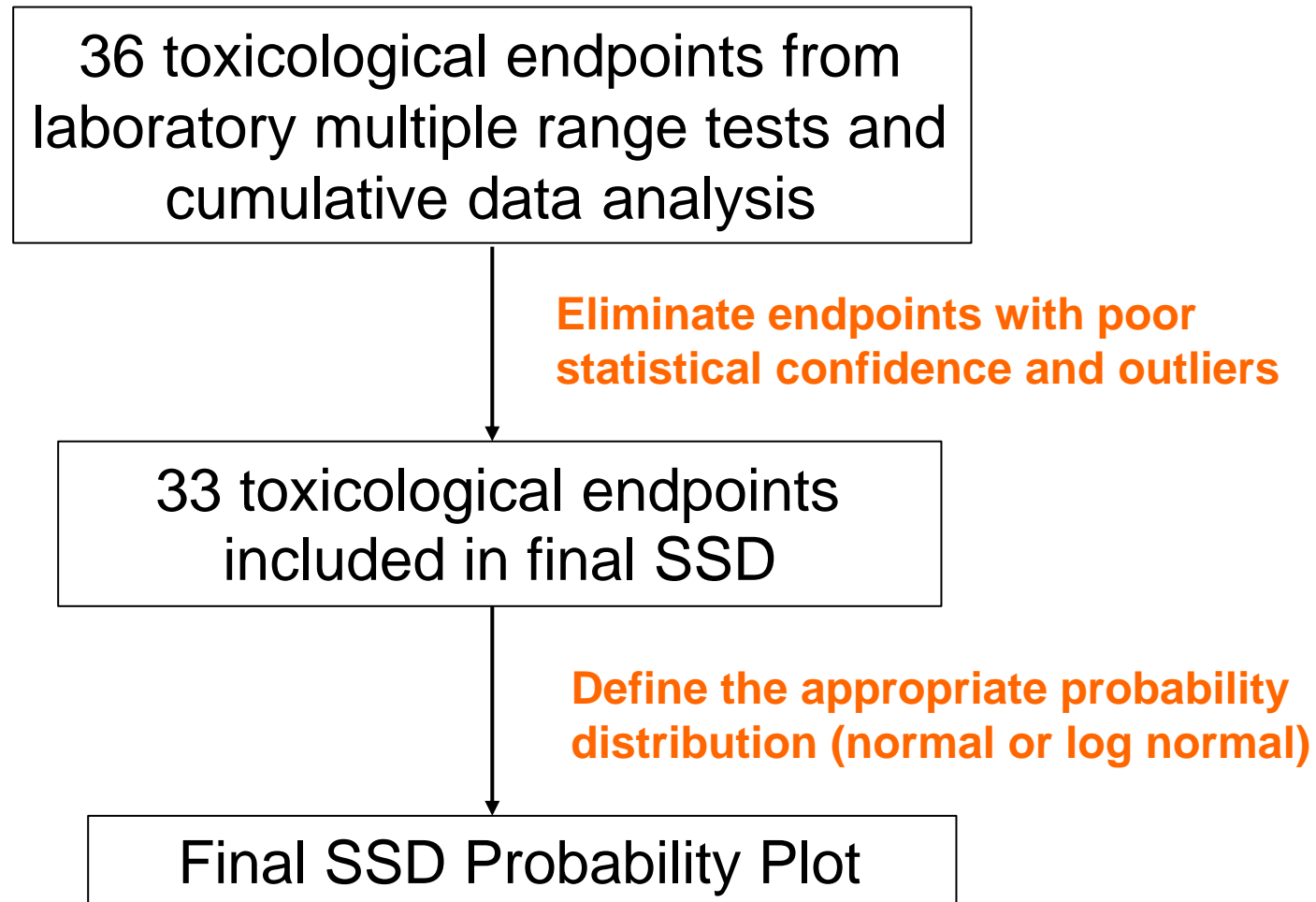


- ❑ Laboratory multiple range dilution testing
 - ❑ median lethal (LC50) or median effects (EC50) concentrations
 - ❑ no observable effects (NOEC) and lowest observable effects concentrations (LOEC)
 - ❑ threshold effects concentrations (TEC)
 - ❑ sub-lethal inhibition concentrations (IC25)

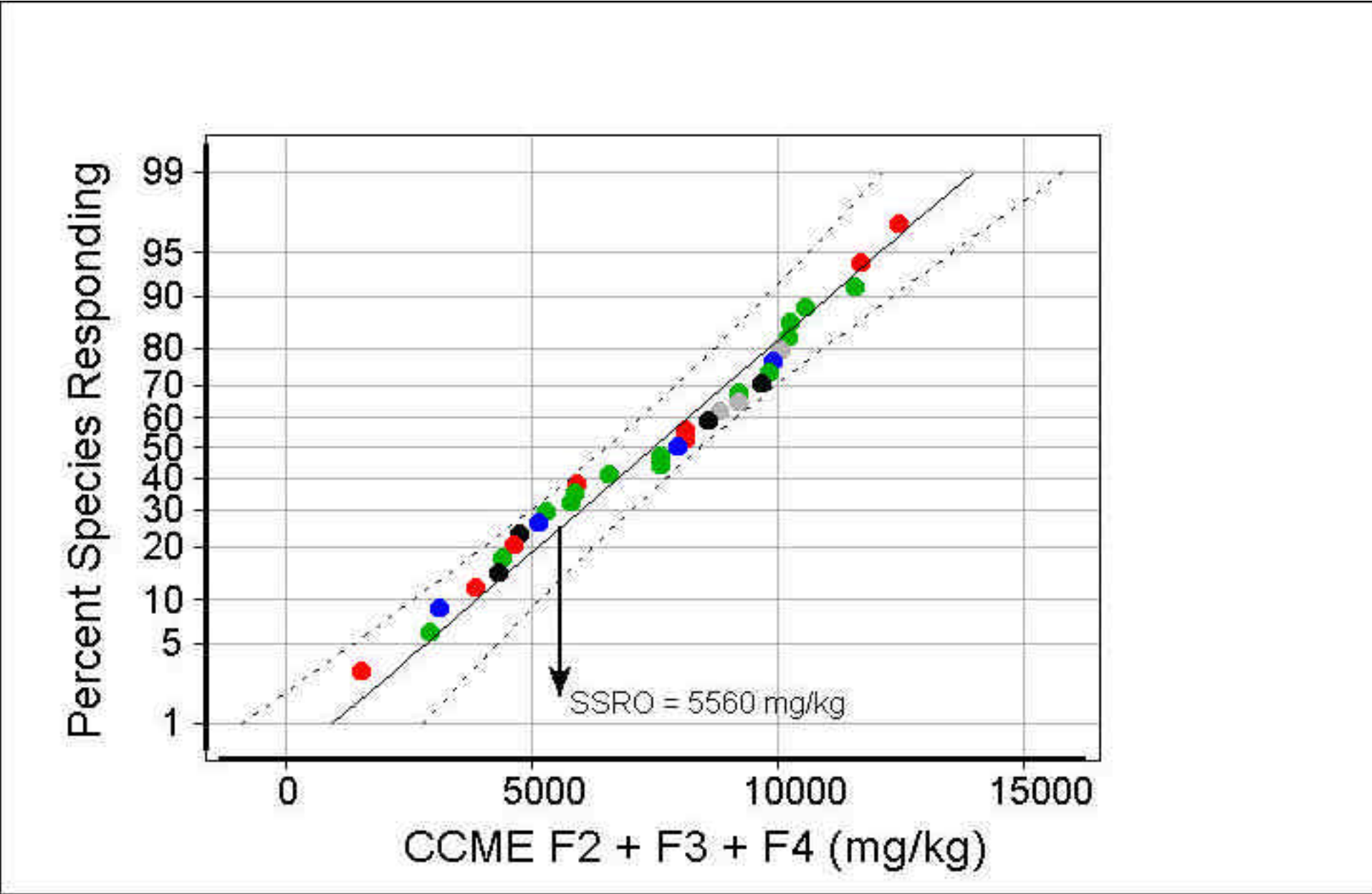
- ❑ Cumulative data mimics multiple range bioassay
 - ❑ median effects (EC50) or low end effects (EC30)

Toxicological Data QA/QC

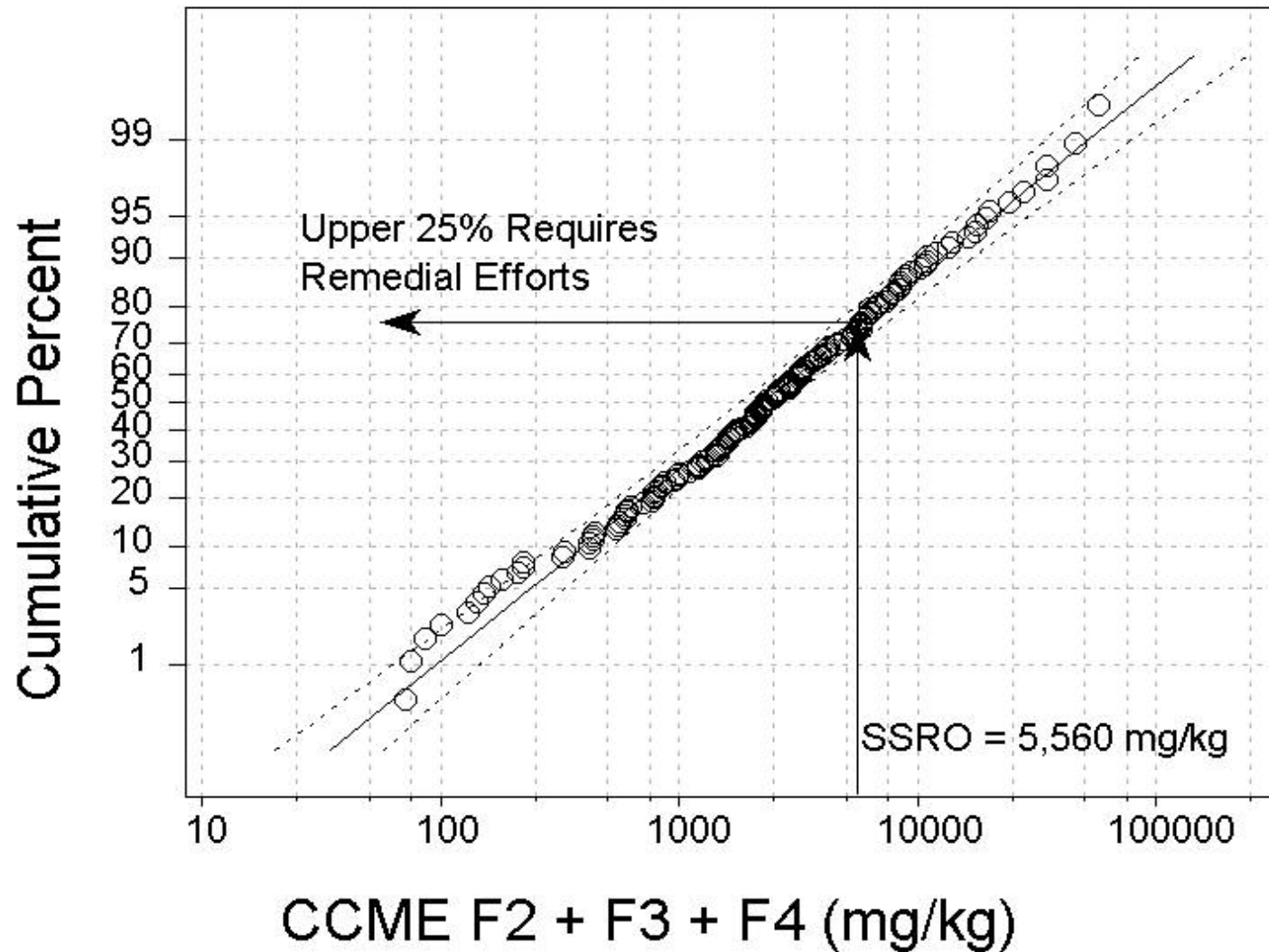
Species Sensitivity Distribution (SSD)



Species Sensitivity Distribution



SSRO Captures 75% of Site-Specific Cumulative Hydrocarbons



Conclusion



- ❑ In terrestrial settings
 - ❑ 5560 mg/kg as compared to cumulative *de minimis* 3350 mg/kg
 - ❑ easier to achieve cumulative SSRO, rather than individually based *de minimis* values, especially F3 criterion of 400 mg/kg
- ❑ In settings with aquatic life receptors
 - ❑ 5560 mg/kg cumulative SSRO still applies with an F2 ceiling of 230 mg/kg
 - ❑ over time the lighter F2 fraction will be degraded