internal report **304**

Expanding the role of ecotoxicology in the Australian wet-dry tropics

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October 1998

supervising scientist

Expanding the Role of Ecotoxicology in the Australian Wet-Dry Tropics

R. A. van Dam

Symposium presentation

"Chemistry and Ecotoxicology in Aquatic Environments"

Royal Australian Chemical Institute – Northern Territory Branch

Northern Territory University, Darwin

21 August 1998

Abstract and overhead sheets used in the presentation are attached.

Some of the information and data presented have been published previously, in Supervising Scientist Reports 110 and 131. It is anticipated that the remaining data will be published in the near future, both as a Supervising Scientist Report, and in a relevant scientific journal.

Expanding the role of ecotoxicology in the Australian wet-dry tropics

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Wetland Risk Assessment, Environmental Research Institute of the Supervising Scientist (***eriss***)

eriss has been carrying out ecotoxicological testing for approximately 10 years. This period has seen the development and refinement of a suite of bioassays thought to suitably represent aquatic ecosystems of the Australian wet-dry tropics. However, reporting on toxicity alone is insufficient if management decisions regarding environmental inputs are required. Therefore, ***eriss*** is building on its ecotoxicological expertise, and focussing on the use of ecological risk assessment approaches to estimate risks of contaminants to aquatic ecosystems. A case study, on the use of the herbicide tebuthiuron on northern Australian floodplains, will be discussed to demonstrate the utility of this expanded approach.

Expanding the role of ecotoxicology in the Australian wet-dry tropics

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Wetland Risk Assessment

Environmental Research Institute of the Supervising Scientist (***eriss***)

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Outline

- History of ecotoxicology at ***eriss***
- Current status of ecotoxicology at ***eriss***
- Why a broadened approach is needed
- Ecological Risk Assessment
- Case study: *Tebuthiuron*

History at *eriss*

- To develop pre-release toxicity testing protocols for the estimation of 'safe' dilutions of Ranger mine retention pond water into Magela Creek

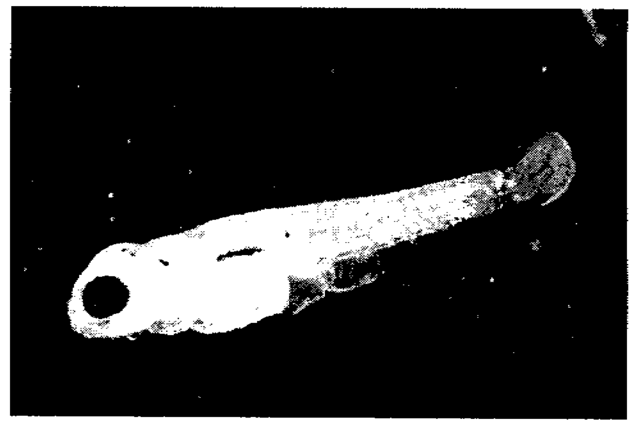
- Approx. 20 local species collected in 1980s and assessed for suitability:

life cycle	*laboratory culture*
test endpoints	*trophic level*
sensitivity	

- 3 species chosen - protocols developed and transferred to Ranger mine Environmental laboratory

Purple-spotted gudgeon

Test species:	*Mogurnda mogurnda*
Age of test animals:	<10 hour old larvae
Measured response:	larval survival
Test duration:	4 days
Acute or chronic:	acute
Habitat:	escarpment streams - floodplains



Freshwater cladoceran

Test species: *Moinodaphnia macleayi*

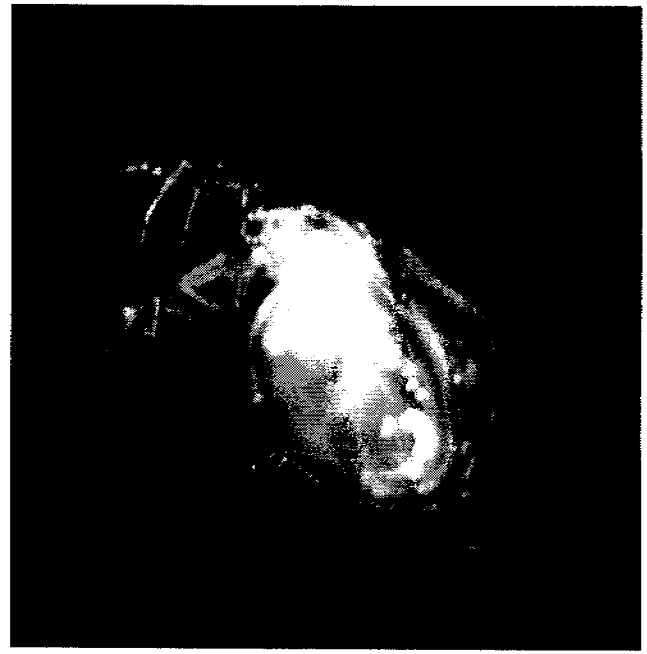
Age of test animals: < 6 hour old neonates

Measured response: total number of offspring per adult

Test duration: 5-6 days/ 3 reproductive broods

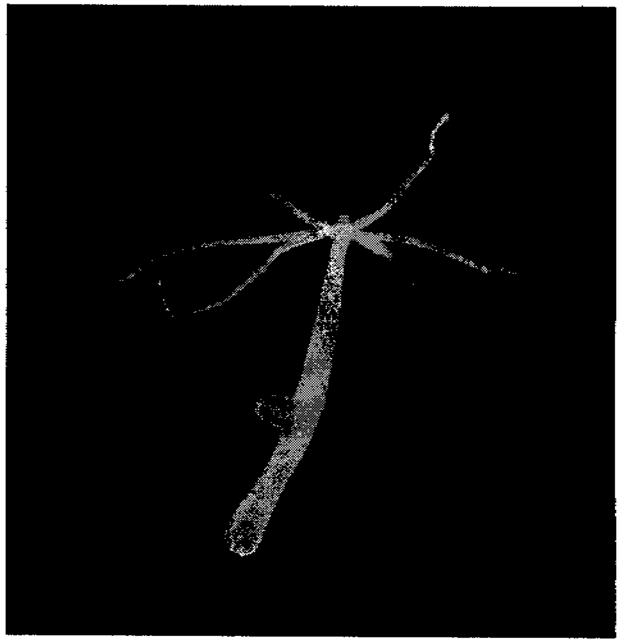
Acute or chronic: chronic

Habitat: permanent billabongs (lentic waters)



Green hydra

Test species:	*Hydra viridissima*
Age of test animals:	adults with 1 asexual bud
Measured response:	population growth
Test duration:	4 days
Acute or chronic:	chronic
Habitat:	permanent billabongs - floodplains (lentic waters)



Current status at *eriss*

- Assessment of environmental contaminants relevant to the Top End/northern Australia
    - uranium, copper, herbicides, natural waters contaminated through mining activities, tourism-associated contaminants, etc.
- Increase flexibility/relevance of suite of tests for assessing wide range of contaminants
- Development of further laboratory-based ecotoxicological protocols
    - Incorporation of aquatic plant species

Duckweed

Test species: *Lemna aequinoctialis*

Age of test plants: mature plants with 3 fronds

Measured response: plant growth/ frond number

Test duration: 4 days

Acute or chronic: chronic

Habitat: permanent billabongs - floodplains

Green alga

Test species: *Chlorella* sp.

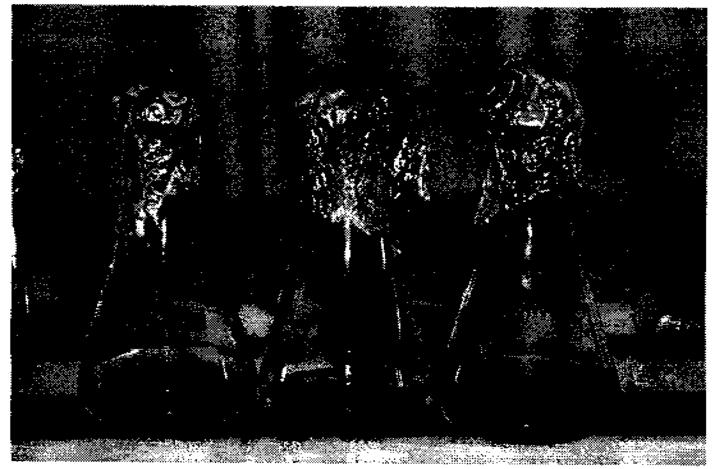
Age of test algae: 4-5 day old culture in exponential growth phase

Measured response: algal cell density/ population growth rate

Test duration: 3 days

Acute or chronic: chronic

Habitat: escarpment streams - floodplains



A broadened approach to assessing contaminant impacts

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- In many cases data on chemical effects provide little useful information for management without knowledge of the level of exposure

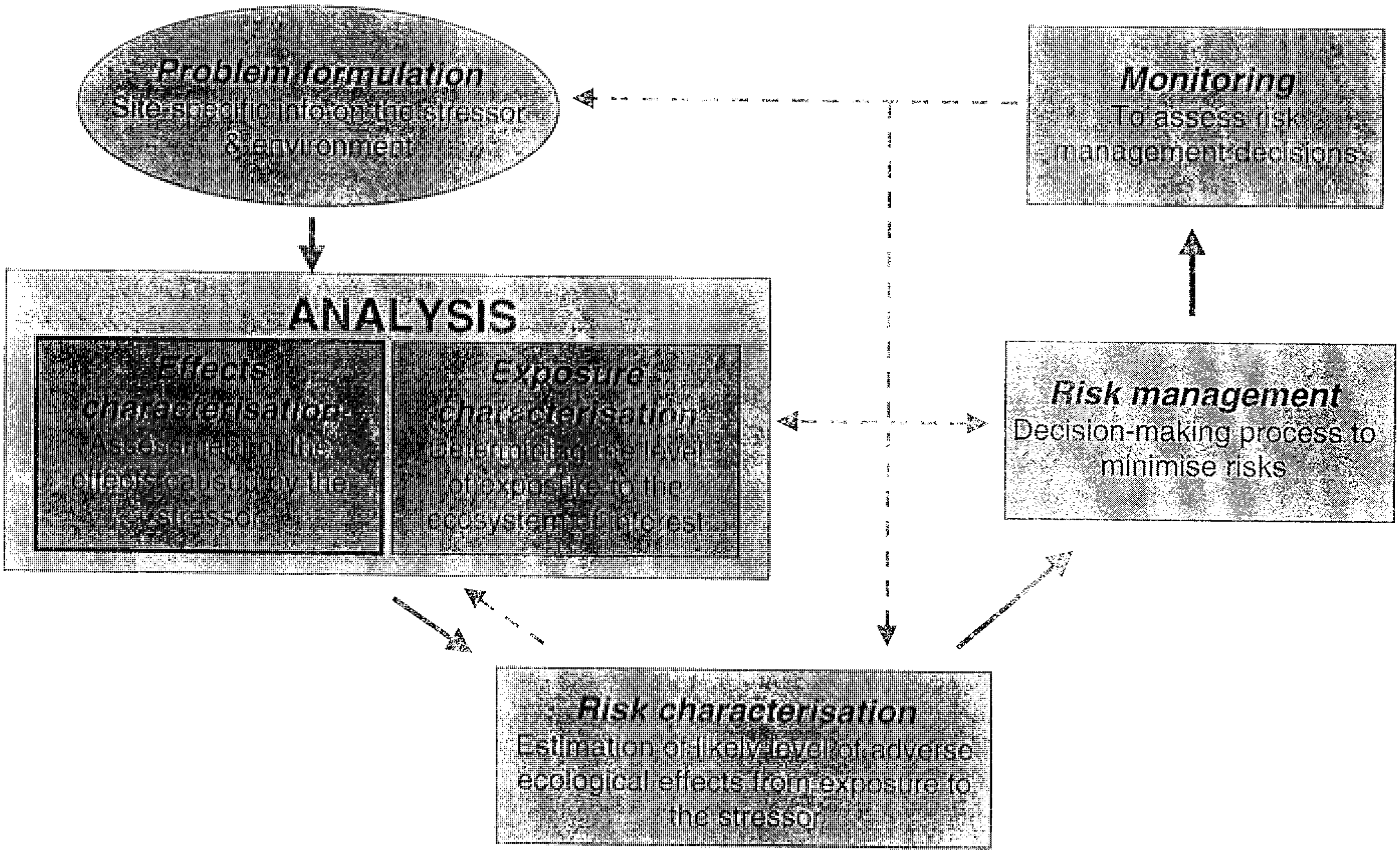
- Land use/management associated with contaminant impacts is a growing issue in northern Australia

  eg *mining* *pastoralism*
  horticulture *tourism*

- Ecotoxicological research should be linked to this management process

  → **Ecological risk assessment**

Ecological risk assessment



Case study

- The stressor: ***Tebuthiuron***

  a herbicide applied in large quantities to *Mimosa pigra* infestations on northern Australian floodplains

- The Oenpelli floodplain:

  1989 - 1500 kg tebuthiuron (1000 ha)
  1991 - 12000 kg tebuthiuron (5800 ha)
  (1998, Koolpinyah Station - 500 kg tebuthiuron)

- Applied at the onset of the wet season

- Risk to local aquatic fauna/flora had not been characterised

Effects characterisation

- Assessment of the toxicity of tebuthiuron to local aquatic fauna and flora

- Laboratory toxicity assessment only

- Comparison with toxicity values for northern hemisphere species (can we use other data?)

→ Determination of *predicted no-effect concentration (PNEC)* for first level assessment (screening).

→ Cumulative probability distribution of species sensitivity to tebuthiuron for further estimation of risks if required

Toxicity assessment results

Organism	EC/LC50 (mg/L)	NOEC (mg/L)	northern hemisphere species toxicity
Gudgeon	214	200	112 - >160 (LC50)
Hydra	150	50	-
Cladoceran	134	20	22 (NOEC)
Duckweed	0.164	0.05	0.09 (NOEC)
Green alga	-	0.05	0.01 - 0.05 (NOEC)

$$PNEC = 0.05 \text{ mg/L}$$

Exposure characterisation

- Chemical monitoring data on the Oenpelli floodplain following tebuthiuron application in 1989 and 1991 (Parry & Duff 1990; Cook 1993)

- Laboratory/field experiments on environmental fate of tebuthiuron in northern Australian floodplain environments (Batterham 1990)

→ Determination of *predicted environmental concentration (PEC)* for first level assessment (screening)

→ Cumulative probability distribution of measured environmental concentrations for further risk estimation if required

Exposure characterisation

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Maximum tebuthiuron concentrations (mg/L) on Oenpelli floodplain
(from Parry & Duff 1990)

	Time after application (days)			
Compartment	**10**	**70**	**98**	**154**
Water	0.55	0.06	0.168	0.034
Suspended sediment/ microalgae	4.39	BADL	BADL	BADL
Soil (0-100mm)	2.91	0.81	1.82	0.35

$PEC = 4.9$ mg/L (water + suspended sediment)

Risk characterisation

Level 1 assessment (screening)

- Risk quotient → ***PEC/PNEC***

  If quotient: < 1 - little or no risk exists
  > 1 - some/significant risk exists

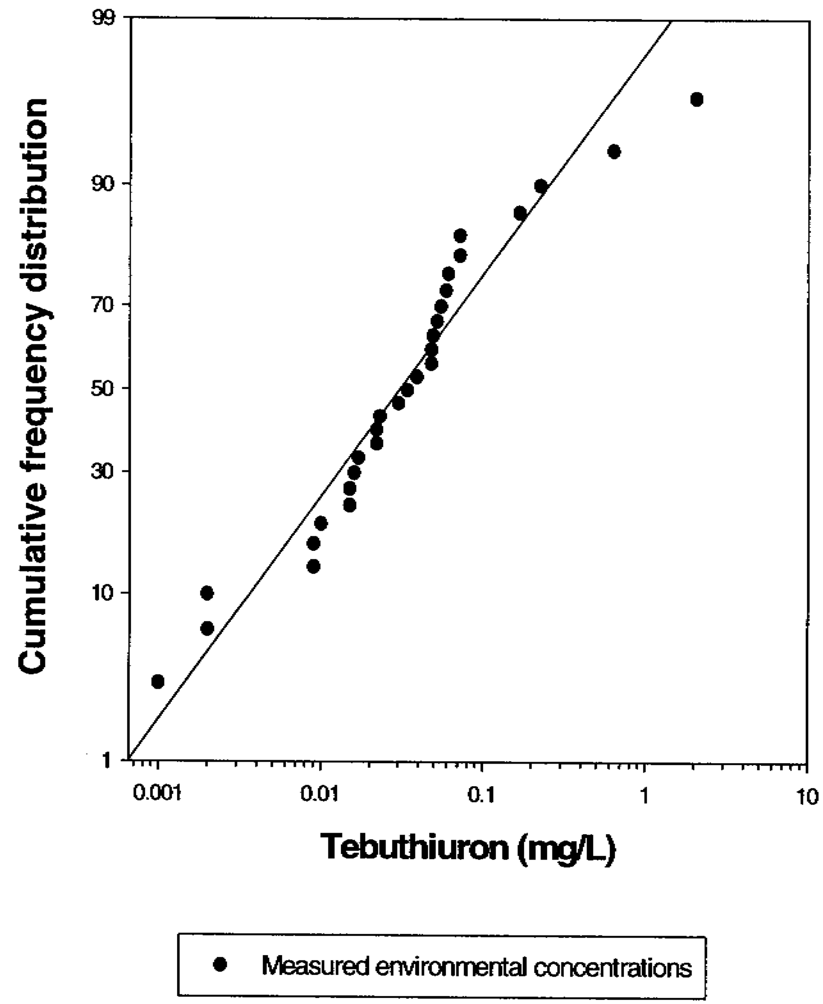
  4.9/0.05 = 98

  Therefore, some/significant risk appears to exist

- Further risk characterisation/estimation required

Comparison of effects and exposure distributions

1. Environmental concs



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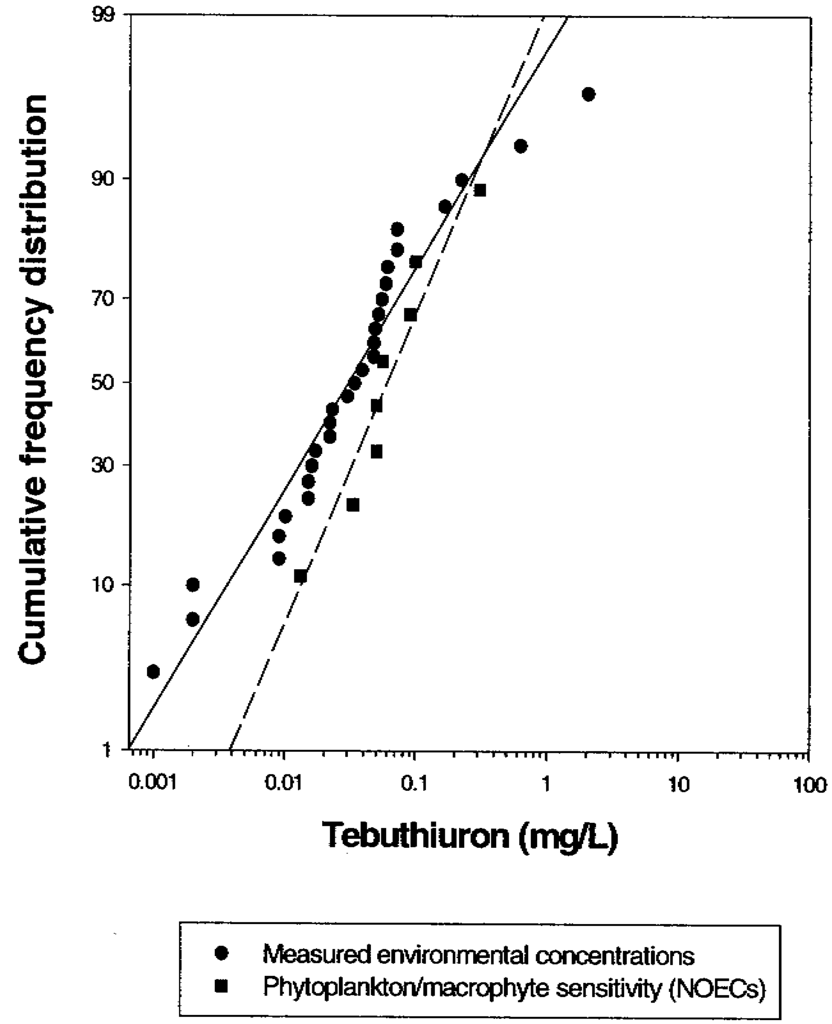
Comparison of effects and exposure distributions

1. **Environmental concs**
2. **Plant sensitivity** (NOECs)



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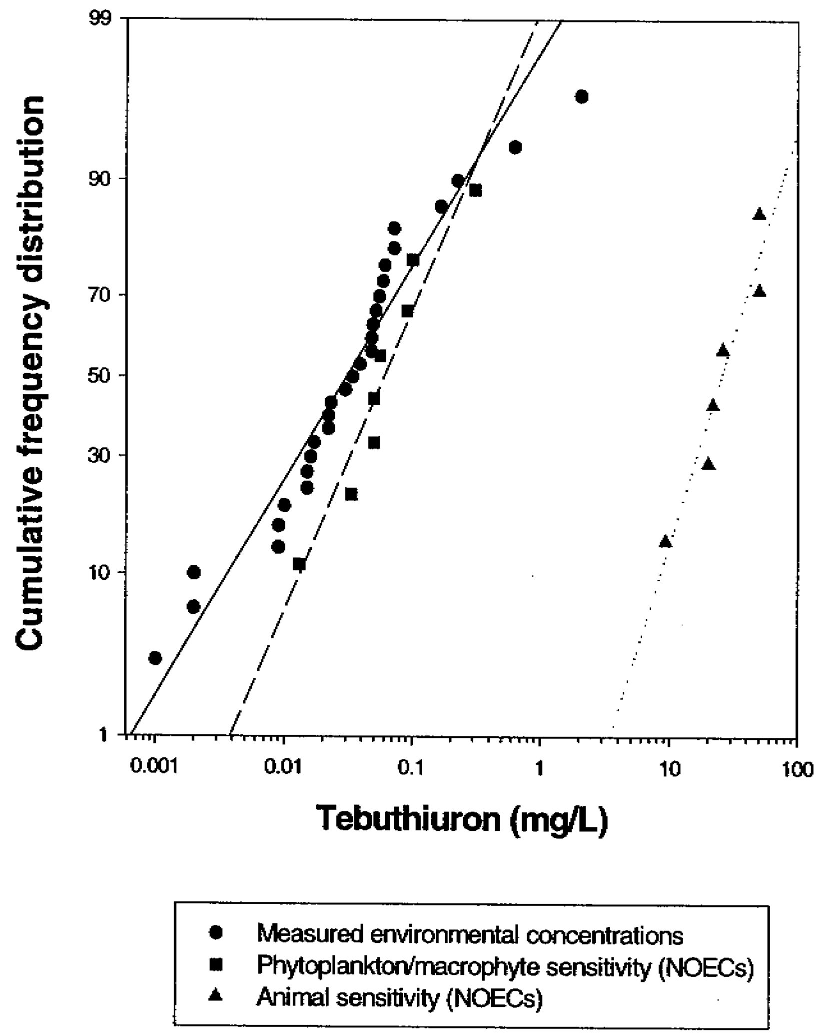
Comparison of effects and exposure distributions

1. **Environmental concs**
2. **Plant sensitivity** (NOECs)
3. **Animal sensitivity** (NOECs)



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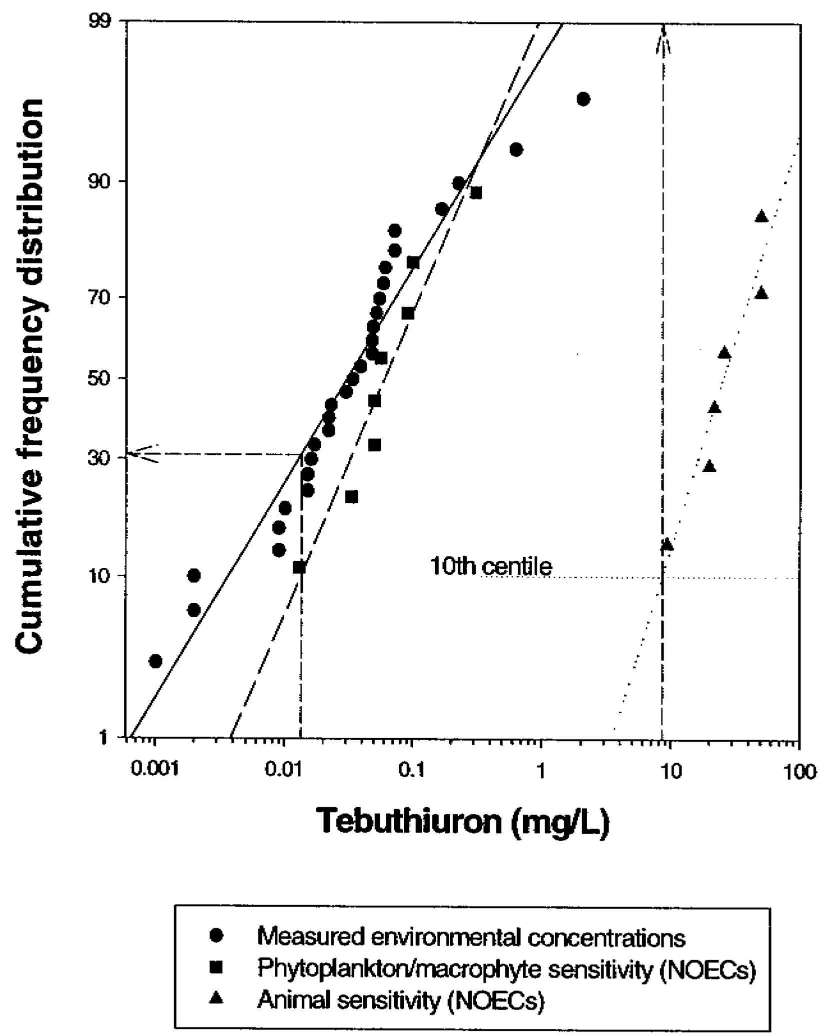
Comparison of effects and exposure distributions

Risk of the *10th* centile of NOEC values being exceeded:

Aquatic plants - ~ 65%

Aquatic animals - < 1%



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Comparison of effects and exposure distributions

After 98 days

Risk of the *10th* centile of NOEC values being exceeded:

Aquatic plants - ~ 63%

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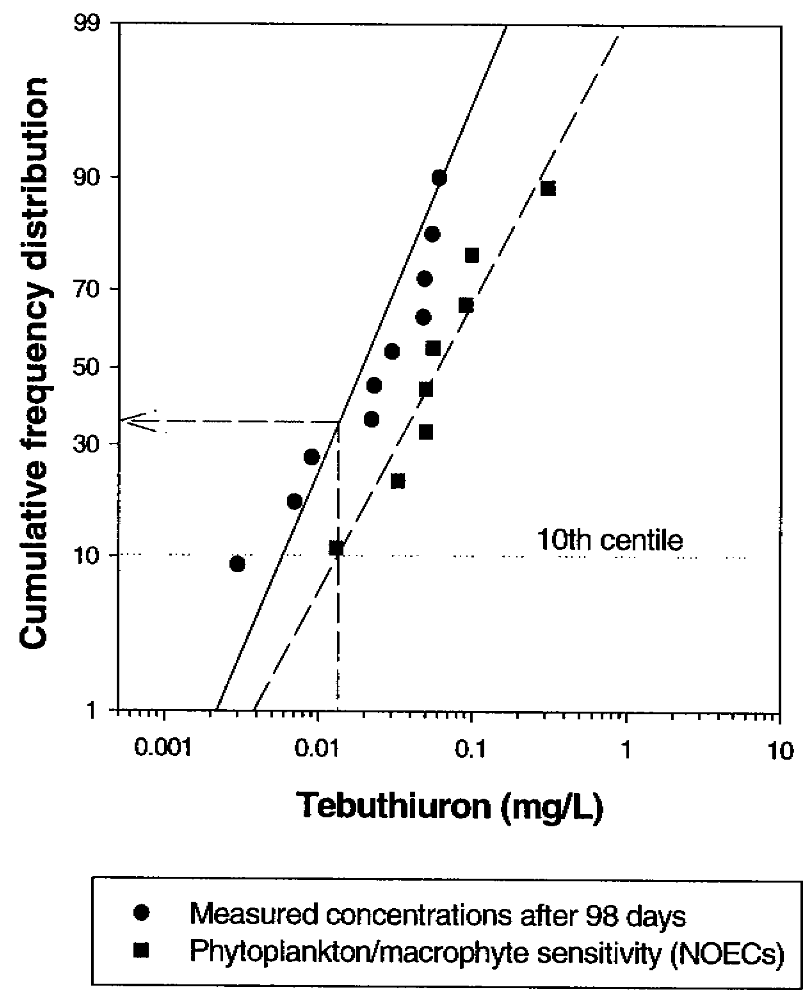

- Output of risk characterisation need not be a quantitative estimate of risk

BUT...

- Need sufficient information for relevant experts to make informed judgments on a weight-of-evidence approach.
- If insufficient info/uncertainty too high, can proceed with another iteration of the risk assessment (partial or whole).
- Uncertainty must always be described

Uncertainty

Effects characterisation

- No field effects data
- Extrapolation from lab effects to field effects; single species to ecosystems
- No information on recovery
- confounding stressors

Exposure characterisation

- Chemical data from 2 large herbicide applications only
- Assumptions on bioavailable concentrations

Risk management

Risk evaluation

- Are effects/exposure data adequate? **Probably require field data**
- Proceed with risk management or collect more data?
  Initial risk management pending further data

Risk reduction

- How does the local community feel?
- Assessment of alternative herbicides
- Improve application methods to minimise off-site contamination

Monitoring

- Required to verify the effectiveness of risk management decisions.
- *Early warning system:* detect failure or poor performance of risk management decisions prior to serious adverse effects occurring.
- What to monitor?
    - Tebuthiuron levels
    - Algal, aquatic macrophyte assemblages
    - Zooplankton, macroinvertebrate assemblages?
- Data can feed back into risk assessment - decreases uncertainty

Summary

- Ecotoxicological tests now developed for a broad range of tropical freshwater organisms/plants.

- Useful for control purposes (ie setting discharge rates) and to provide data for the derivation of WQGs for regionally-relevant toxicants.

BUT

- The use of **ecological risk assessment** provides an important link between ecotoxicological research and land management.

- Identification of uncertainties/information gaps helps identify and prioritise further relevant research.