

Life Cycle Impacts on Human Health and Ecosystems of the most used Pesticides in Costa Rica



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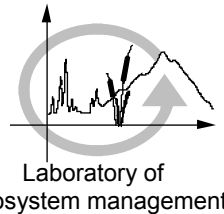
Environmental Science & Engineering

Industrial ecology - Life Cycle Systems

Swiss Federal Institute of Technology of Lausanne

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Introduction



- **Pesticides use and their impacts is a major item of the re-orientation of agriculture towards sustainable development.**
- **Developing countries that are agricultural exportator often use pesticides forbidden in developed countries.**
- **Costa Rica is a good study case**

Objectives of the Study



To propose substitutions between pesticides to achieve reduction in impacts while keeping the same function

Methodology: Types of Expositions



- Impact on Human Health

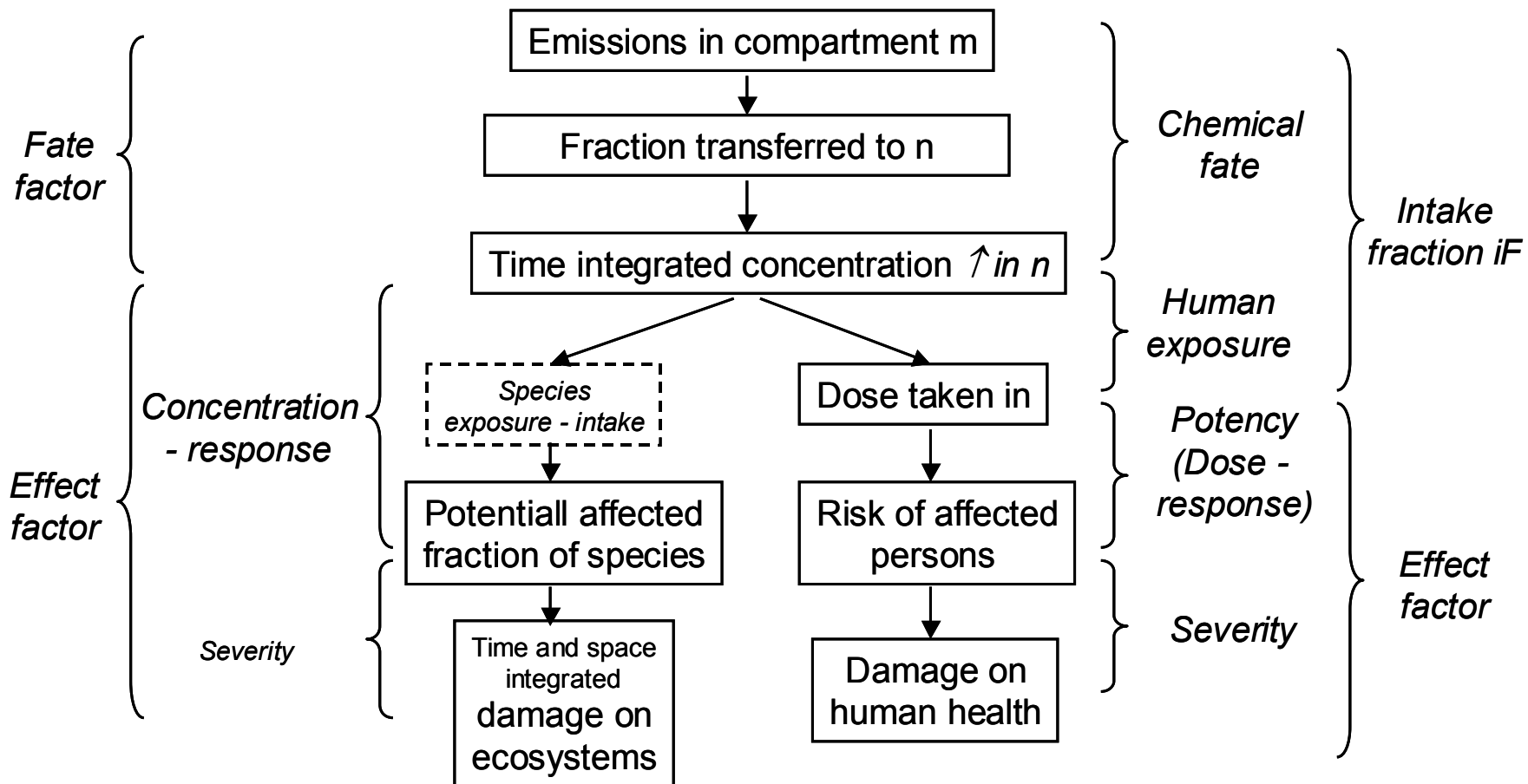
1. Single exposure, short duration; accidents
2. Long-term exposure, high level; workers
3. Long-term exposure, low level; population

- Impact on Ecosystems

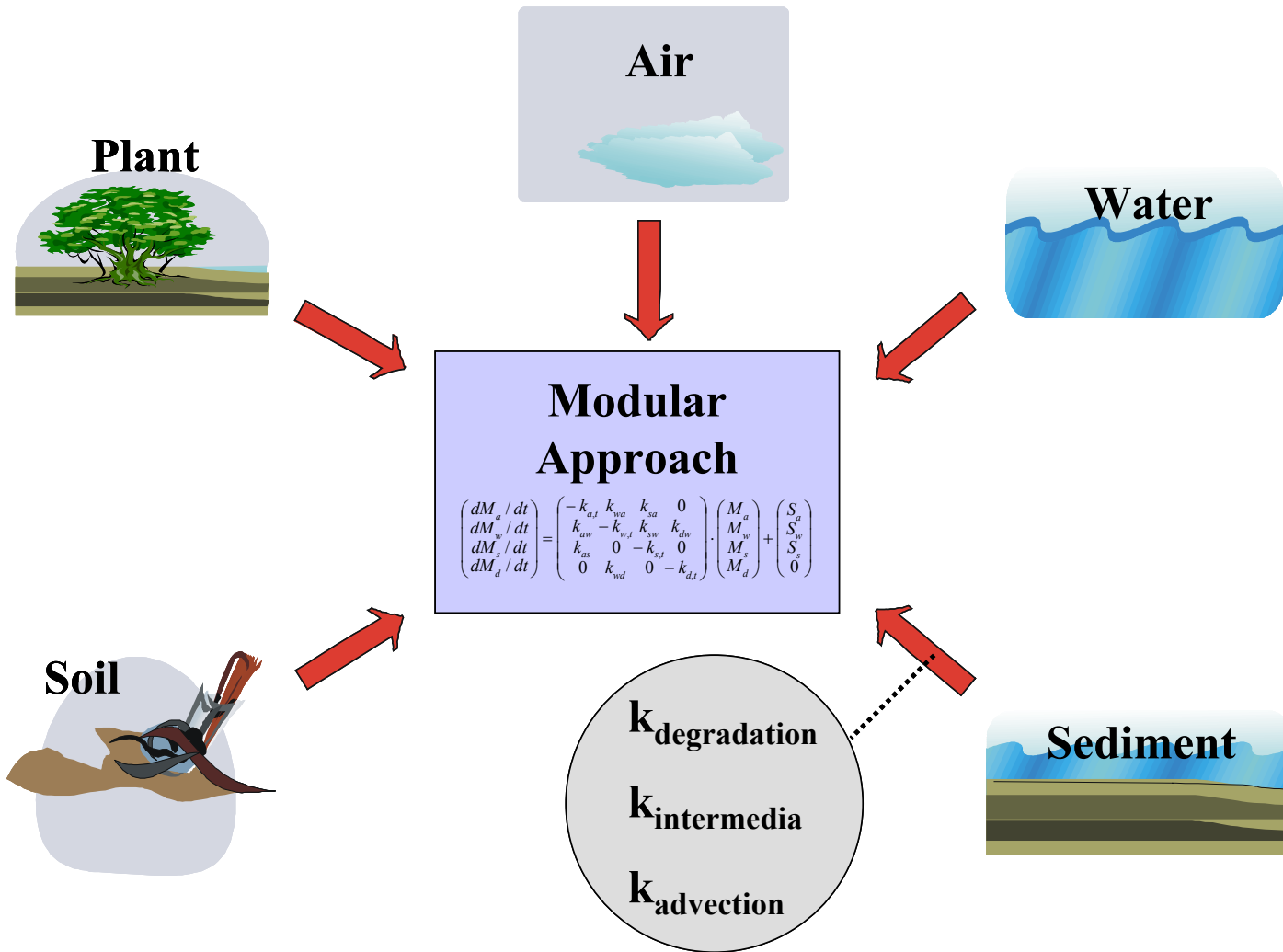
4. Short-term exposure, high level; in the field
5. Long-term exposure, low level; wildlife

IMPACT2002

(Impact assessment of chemical toxicants)



Multimedia model based on equations of mass bilan



Dynamic Model for Pesticides Residues in Plants (FITP)



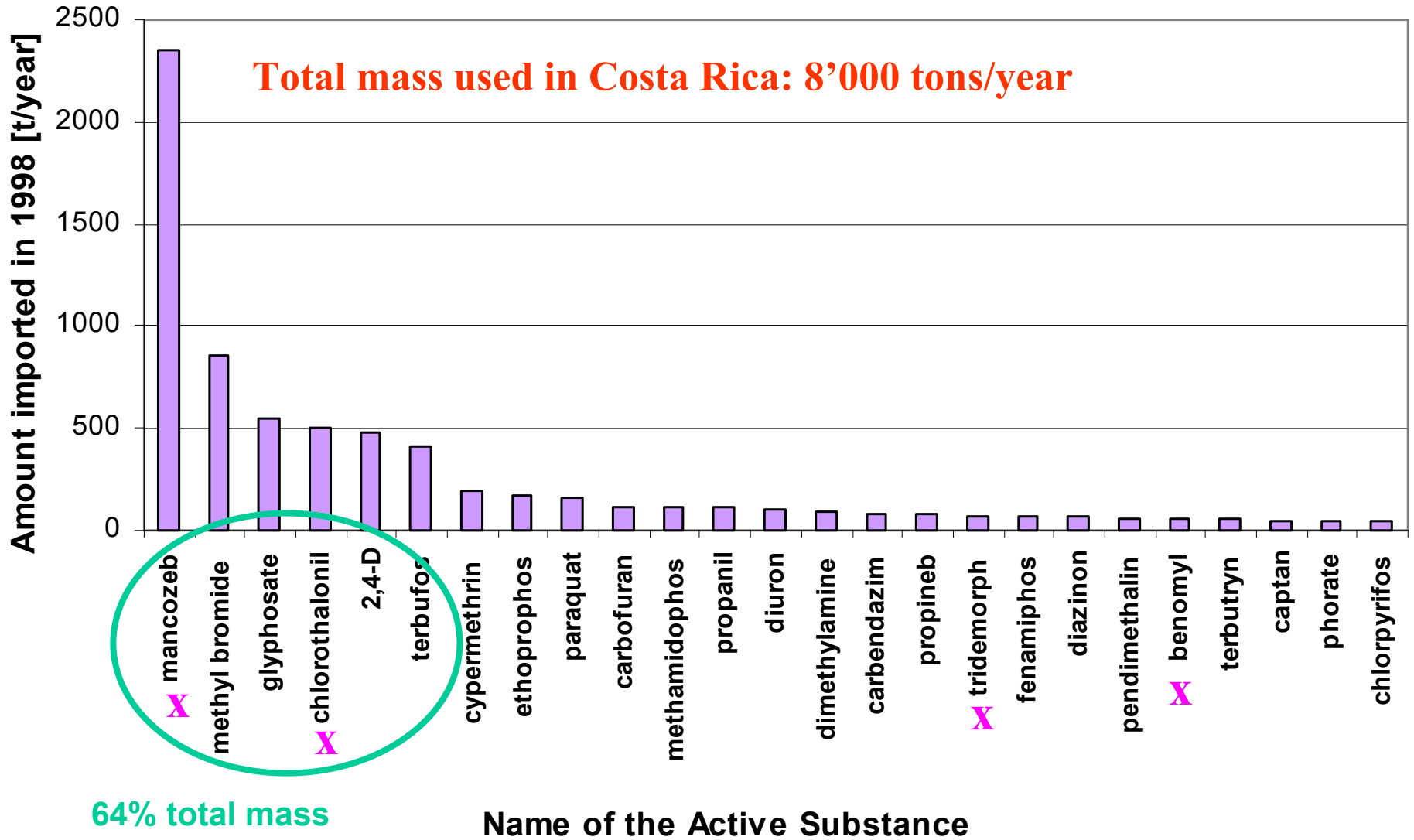
- **Developed by Raphael Charles**
- **Because Impact2002 does not consider direct application on the plant**
- **Plant Compartment**
- **Model-Plant: growing period of 150 days & 1 kg dry matter per m² at the harvest**

Results

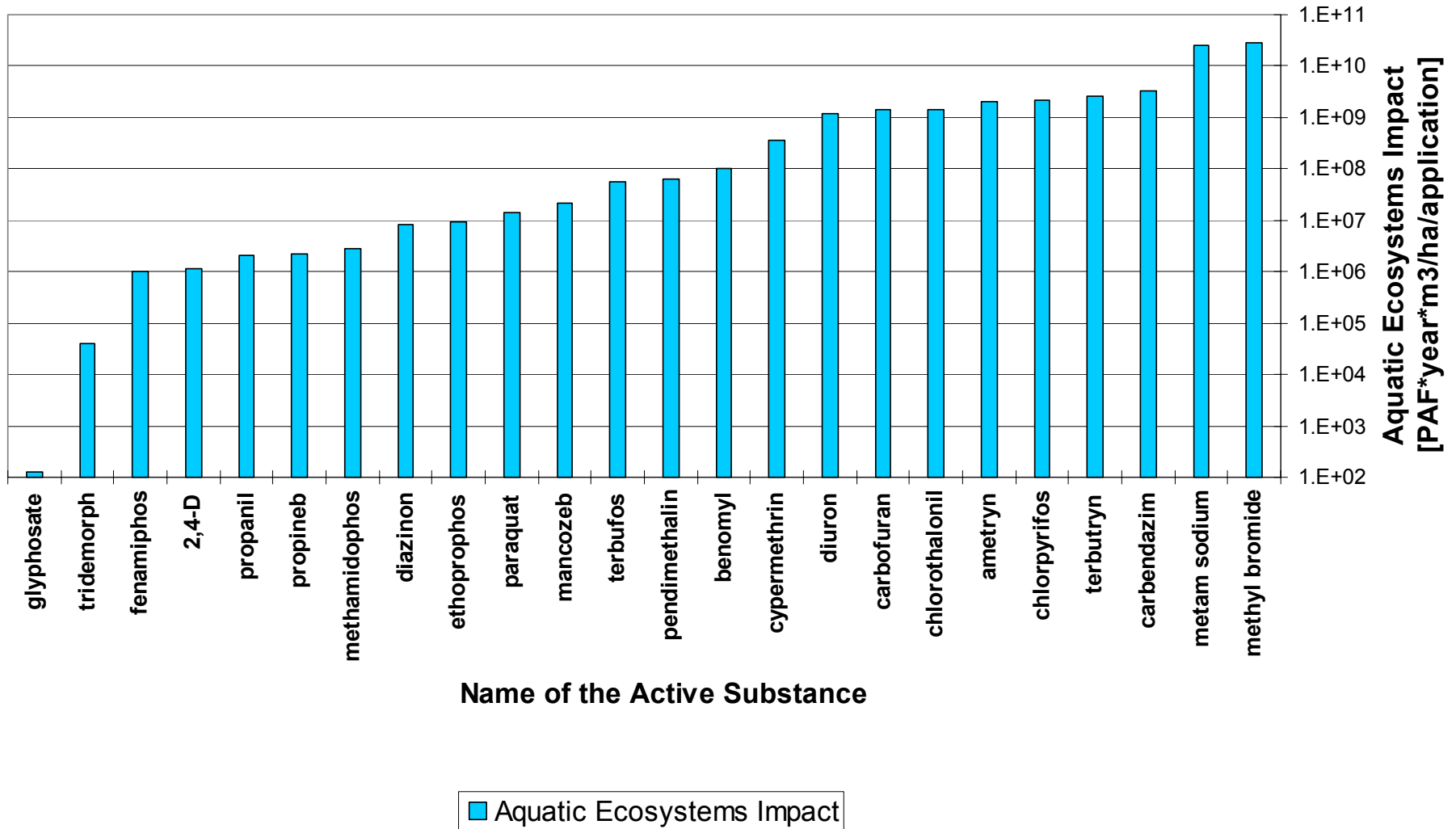


- **(25) Active Substances most used in Costa Rica (1998)**
- **Active Substance ⇔ Pesticide**

Active Substances most used in Costa Rica (1998):



Aquatic Ecosystems Impact per Application (per ha) (Impact2002)



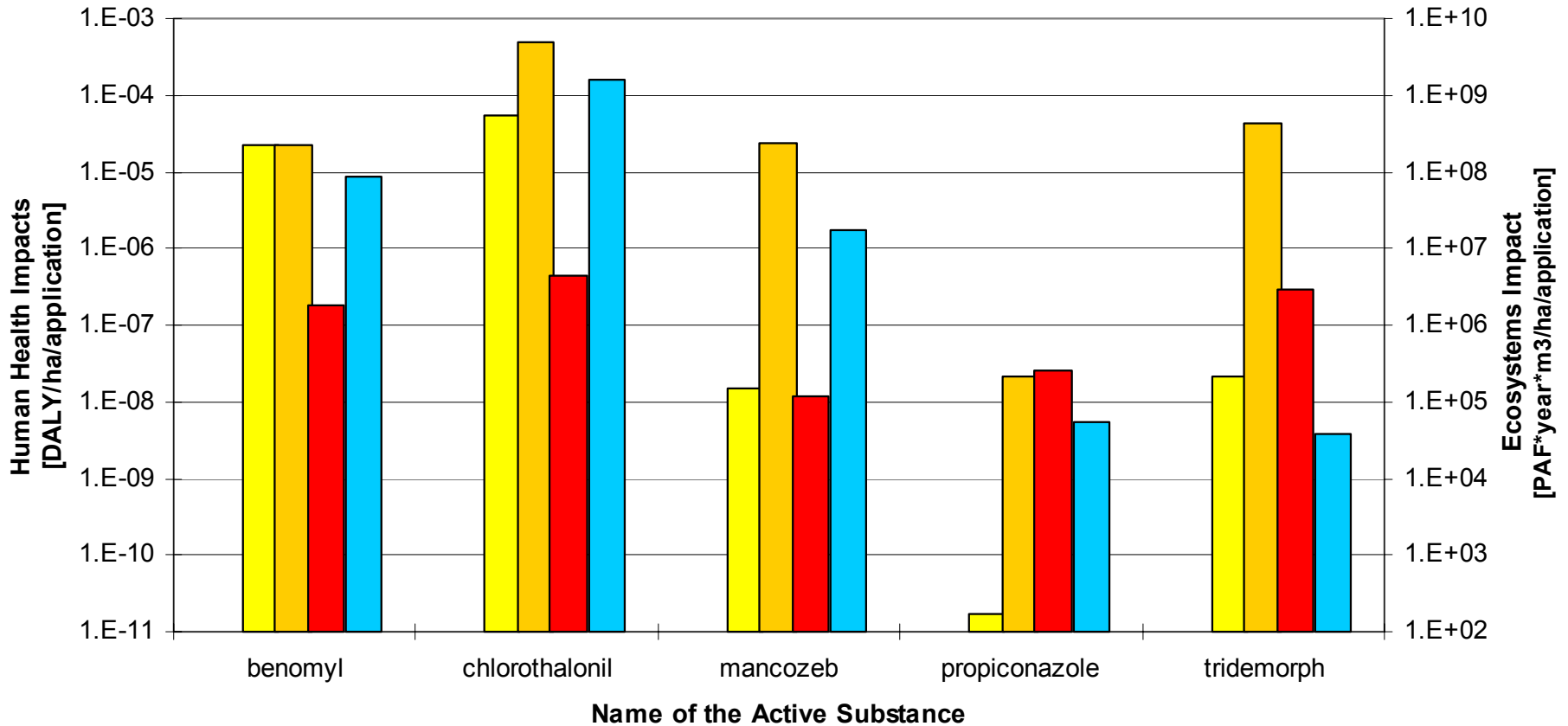
Substitution case in details



**Fungicides
against Cercospora Leaf Spot
in banana plantations**

Impacts on Human Health and Ecosystems for Fungicides (against Cercospora Leaf Spot) used in bananas plantations (Impacts per HA, for 1 application)

Impacts per kg x DOSE



■ Human Health Impact due to Residues (75 days)
 ■ Human Health Impact due to Residues (20 days)
 ■ IMPACT2002 Human Health Impact
 ■ Aquatic Ecosystems Impact

Limits of the Study



- **Model FITP should be better adapted**
- **Feasible but still not incorporated in Impact 2002:**
 - **Terrestrial Ecosystem Impacts**
 - **Degradation Products Impacts**
 - **“Inert” ingredients (impacts and effects on active substances)**
- **These results do not account for:**
 - **Work Environment Impacts**
 - **Extern Impacts (fabrication, ozone, ...)**

Conclusions




- **Great incertitudes (factor 100)**
- **Diffuse impacts are generally lower than impacts caused by residues in treated plants.**
- **Key parameters:**
 - time between treatment and harvest.
 - plant degradation half life.
- **First “Screening”**
- **Help for decision WITH complements**

**Thank you for your interest
and have a nice meeting**

SH, OJ, EPFL, 2003

Annexes

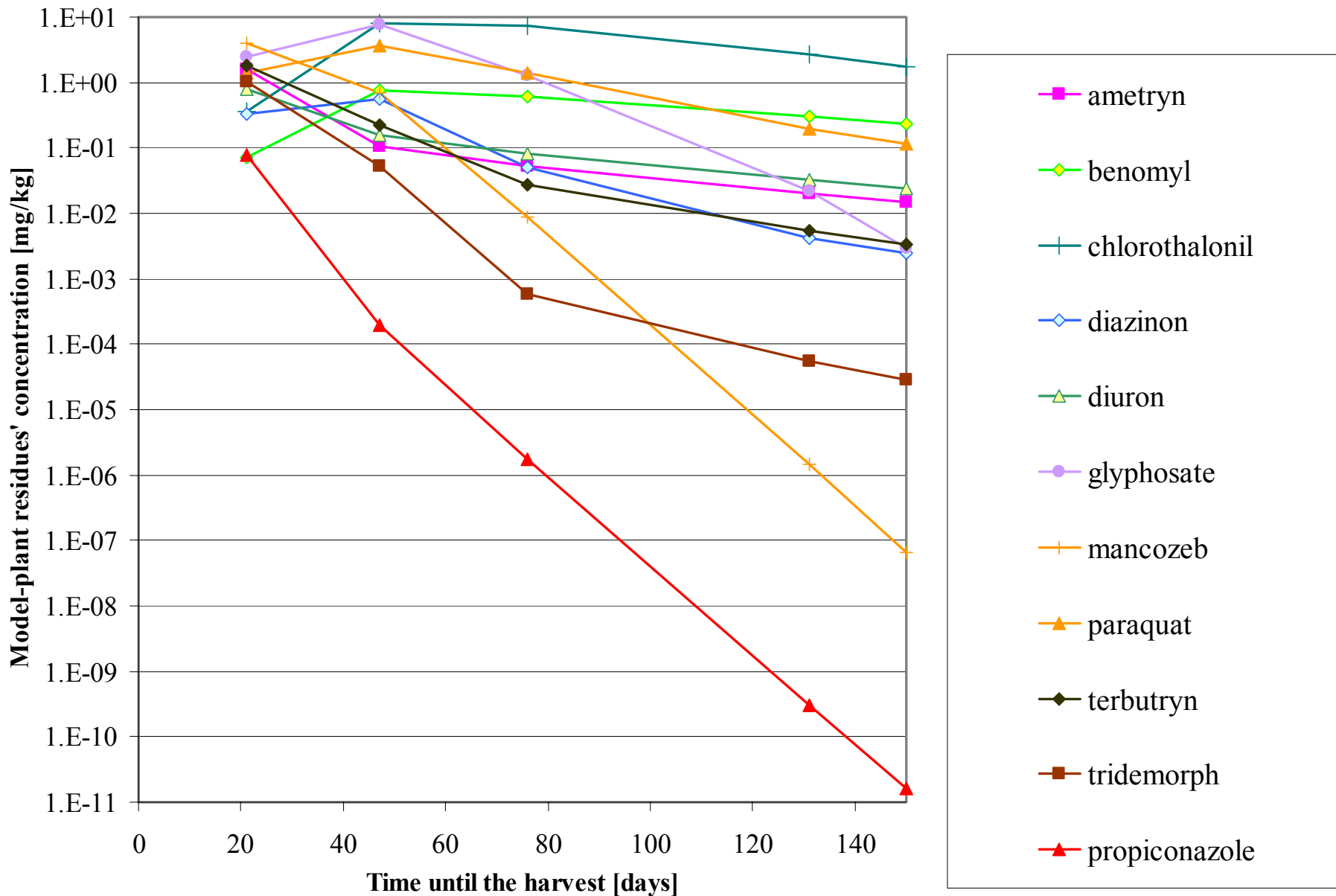
- 
- 1. Impacts per Application for Herbicides
 - 2. Impacts per Application for Fungicides
 - 3. Impacts per Application for Insecticides
 - 4. Impacts per Application for Nematicides
 - 5. Impacts per Application for Acaricides

Main Elements

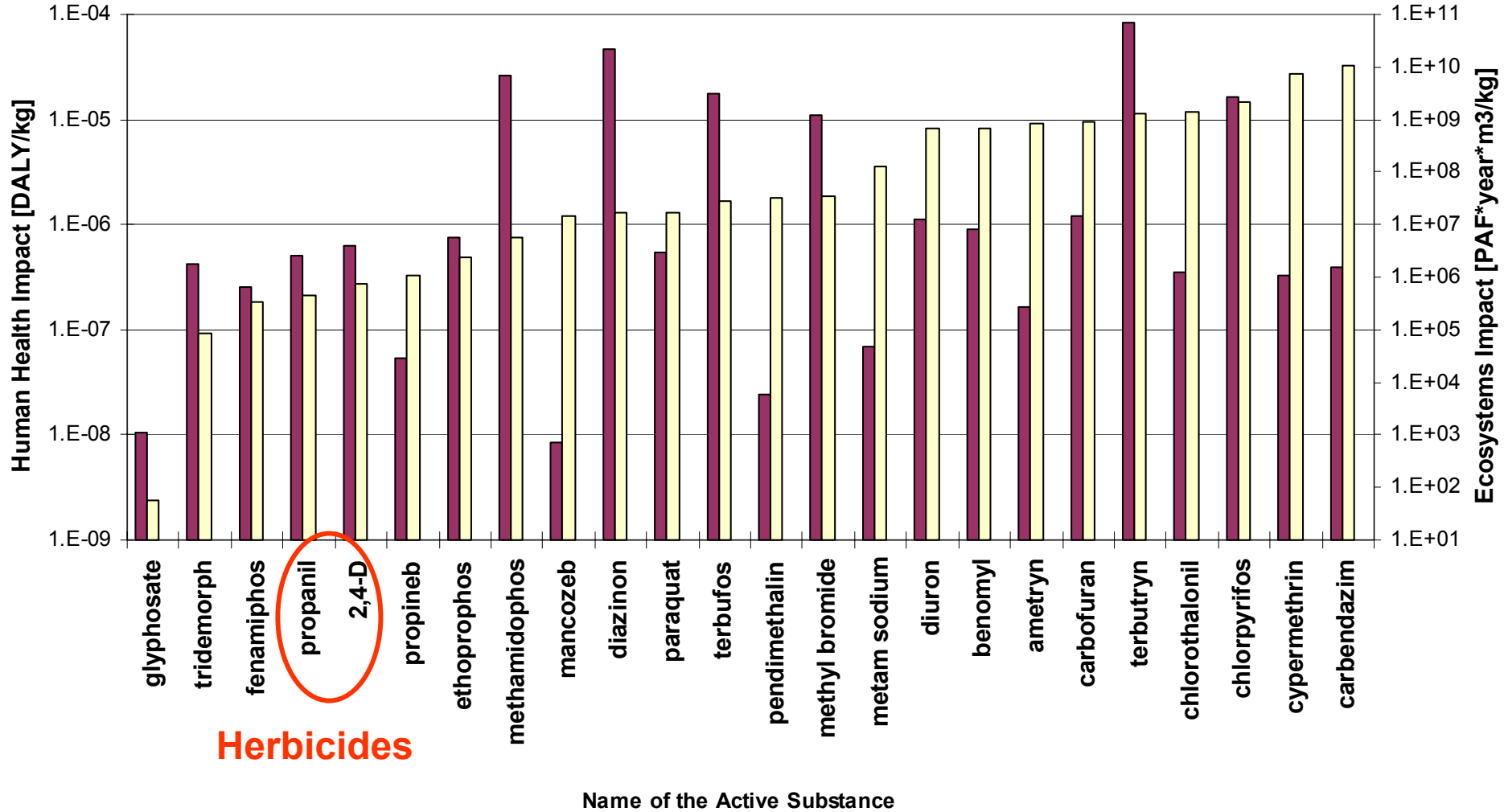


- For a same function (*functional unit*)
 - (1 person transported on 1 km,
1 m² livable during 1 year,
1 treatment with herbicide on 1 ha, ...)
- Impact on the Human Health
- Impact on the Ecosystems
 - (animals, vegetals, landscape, ...)
- Impact on the Natural Resources
- Impact Social & Economic

Evolution of the model-plant residues' concentration (without the residues on the surface) for a treatment 130 days before harvest

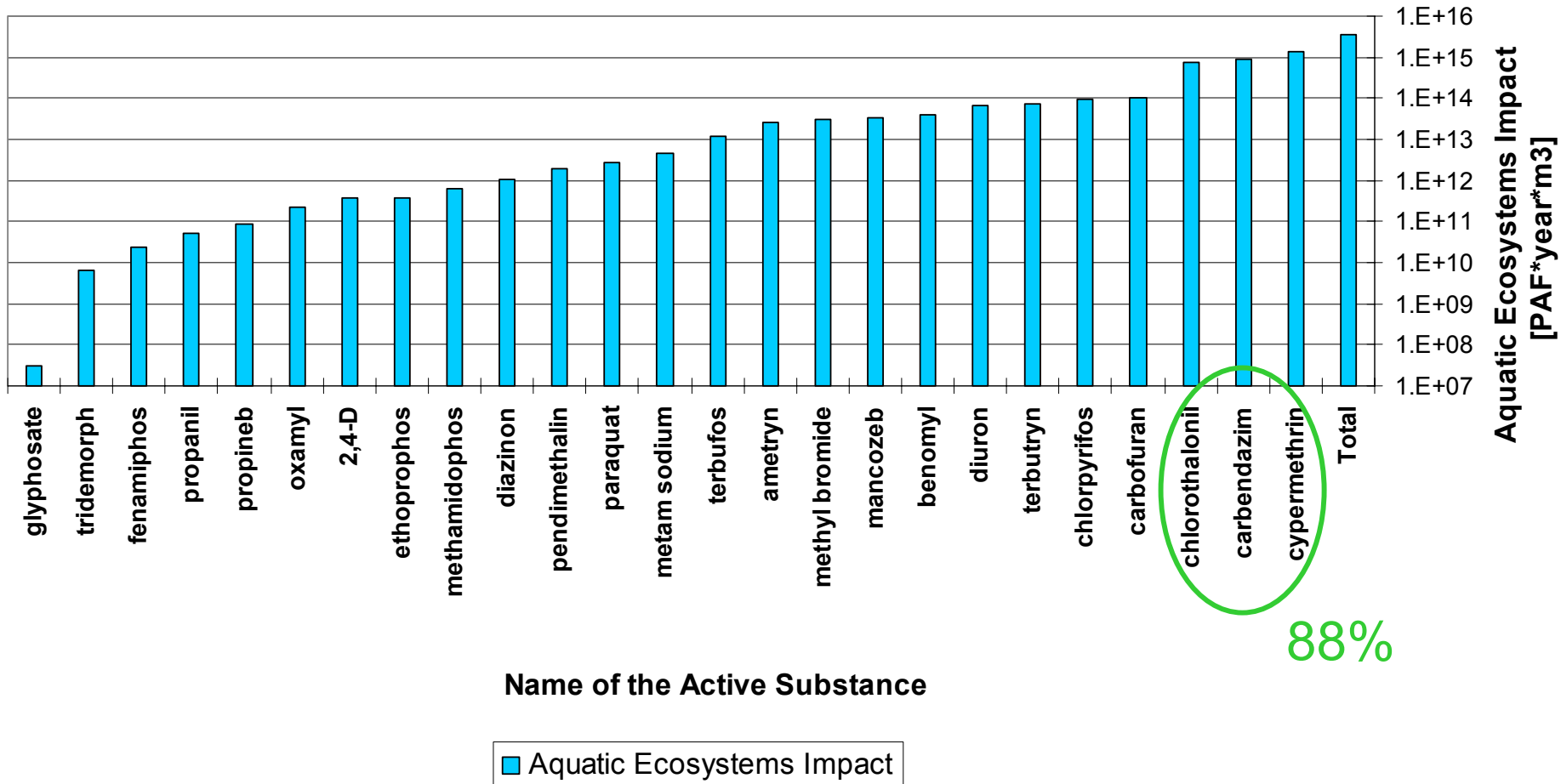


Human Health and Ecosystems Impact (per KG of pollutant emitted) (Impact2002)



■ Human Health Impact □ Ecosystems Impacts

Total Aquatic Ecosystems Impacts per pesticide in Costa Rica in 1998 (Impact2002)



Conclusions on the 25 Actives Substances most used in Costa Rica in 1998 (Impact2002)

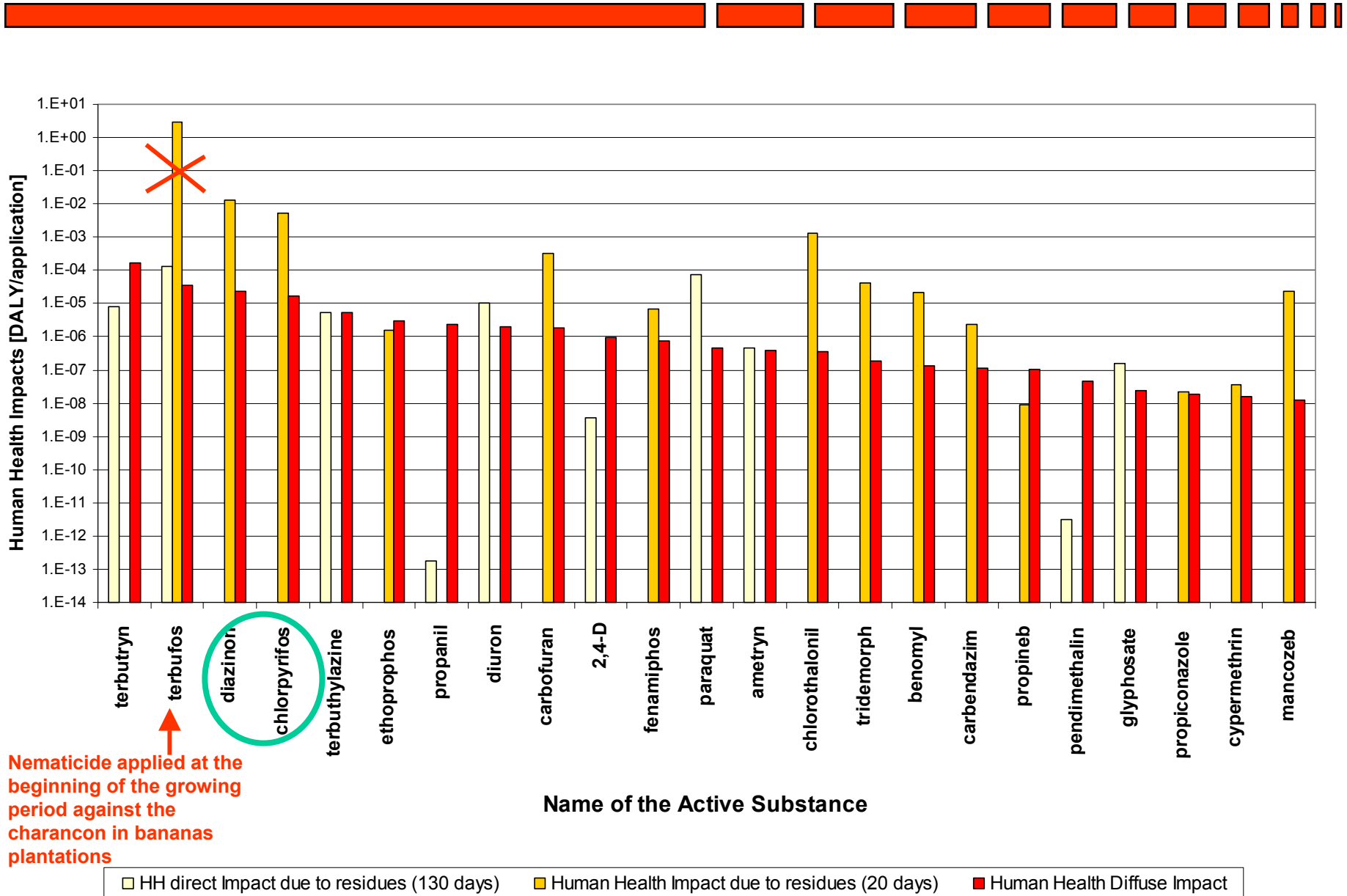


- **Total Impact: 30 DALYs**
 - **Impact on Human Health: 95% caused by 5 AS!**
methyl bromide (33%), terbufos (25%), terbutryn (16%), diazinon (11%) & methamidophos (10%).
The five = 1,507 t (=22%)!
 - **Impact on the Ecosystems: 88% caused by 3 AS!**
cypermethrin (41%), carbendazim (26%) & chlorothalonil (21%).
The three = 784 t (=11%)!

Impacts caused by residues in the treated plants

- **Model FITP**
- **Model-Plant (150 days g.p., 1kg d.m./m²)**
- **Three treatments:**
 - 130 days before harvest
 - 75 days before harvest
 - 20 days before harvest

All Human Health Impacts per Application (per ha)



Observations



- **Impacts caused by residues in treated plants are generally higher, but also sometimes lower than « diffuse » impacts.**
 - **Total impacts (in 1998) for the 30 most used pesticides:**
 - 500 yr lost (if application >75 days before harvest). Caused mainly by chlorothalonil (fungicide, 6% of total used mass but 80% of the impact).
 - 3'000 yr lost (if application >20 days before harvest). Caused mainly by diazinon (insecticide, 1% of total used mass but 60% of the impact).
- => Impacts caused by residues in treated plants are globally more important than diffuse impacts.**
- **Key parameters:**
 - time between treatment and harvest
 - plant degradation half life.

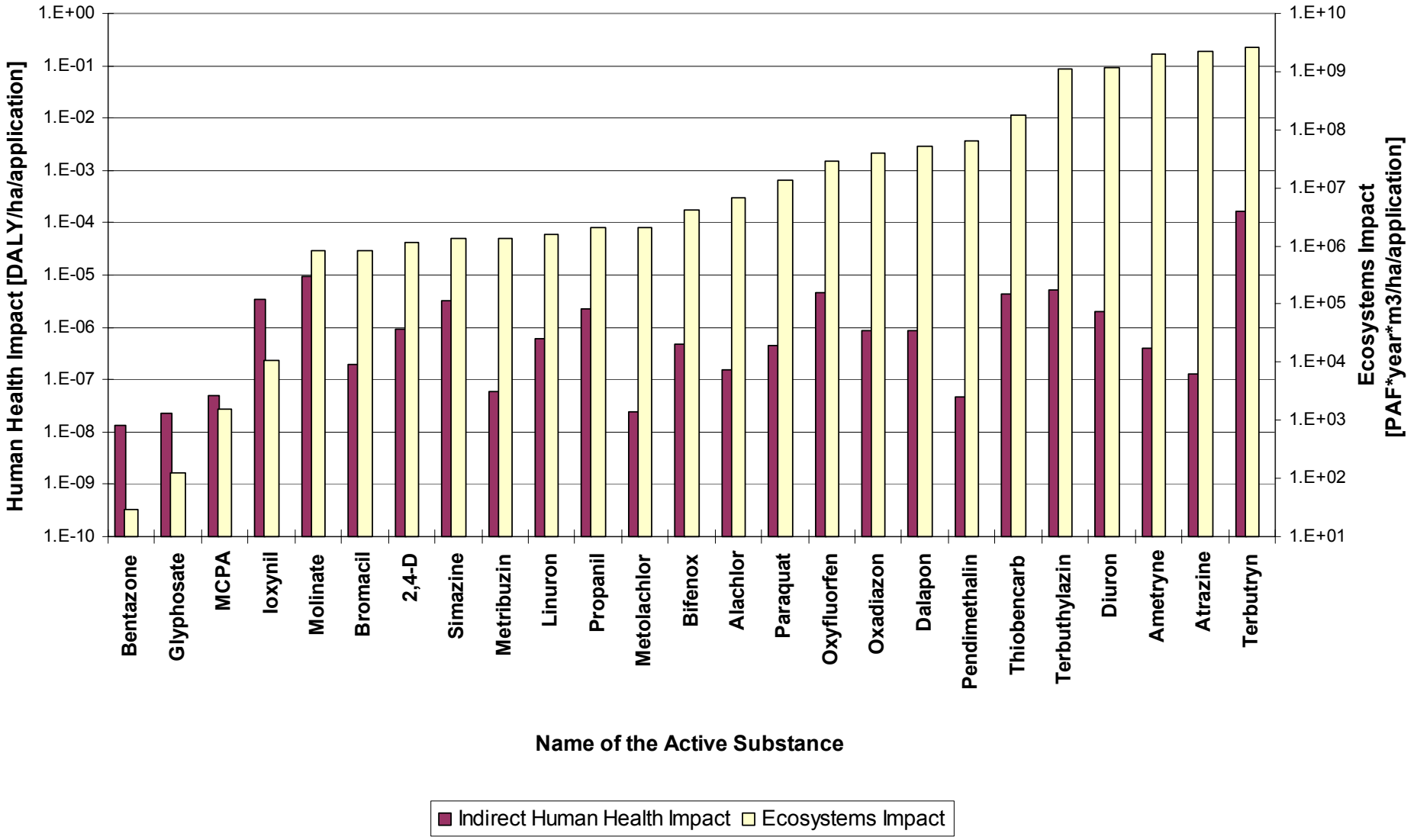
Active Substances by classes of Pesticides



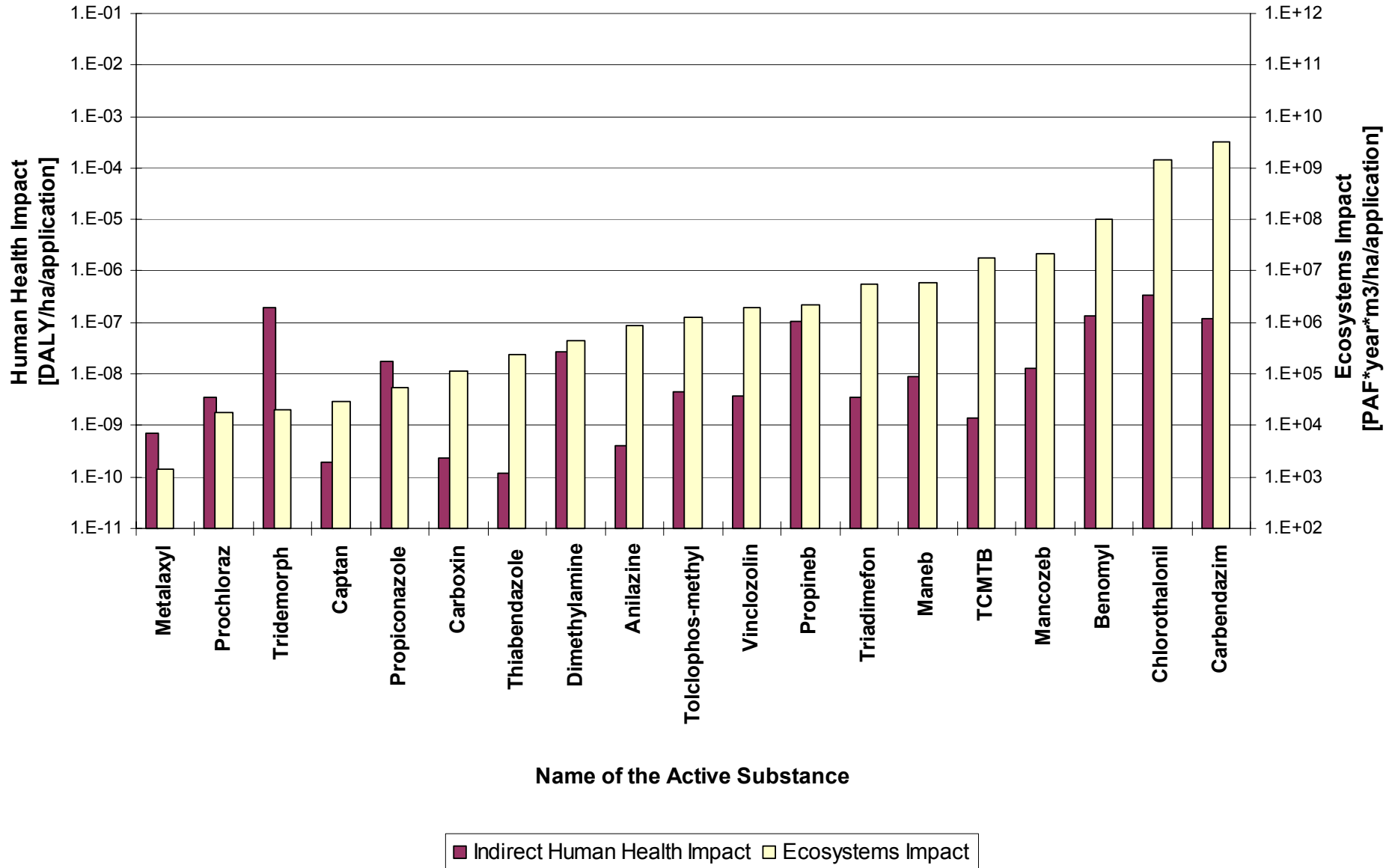
- **Biocides**
- **Herbicides**
- **Fungicides**
- **Insecticides**
- **Nematicides**
- **Acaricides**
- ...

=> comparison and substitutions !!

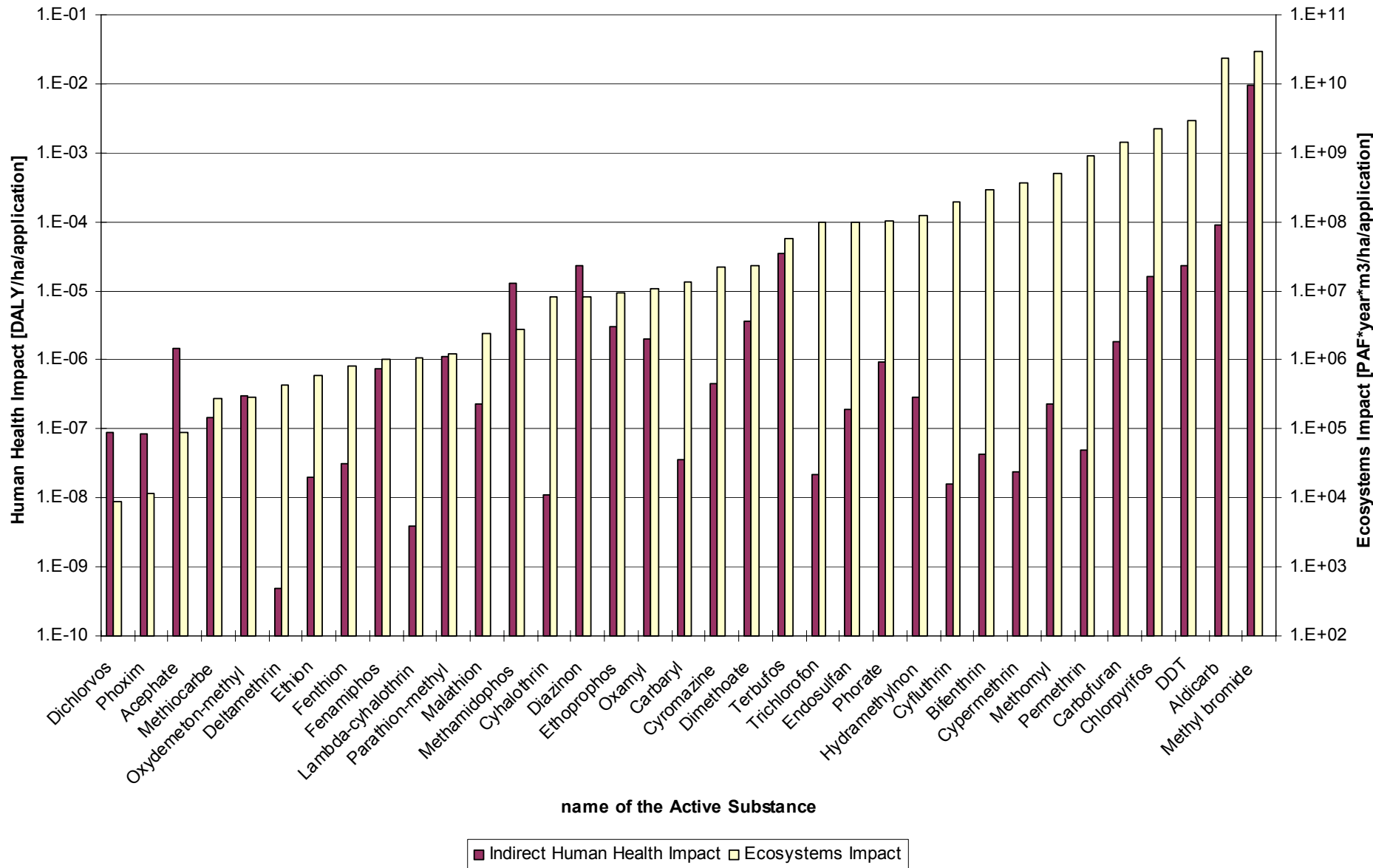
"Indirect" Human Health and Ecosystems Impacts for HERBICIDES (per HA, for 1 application)



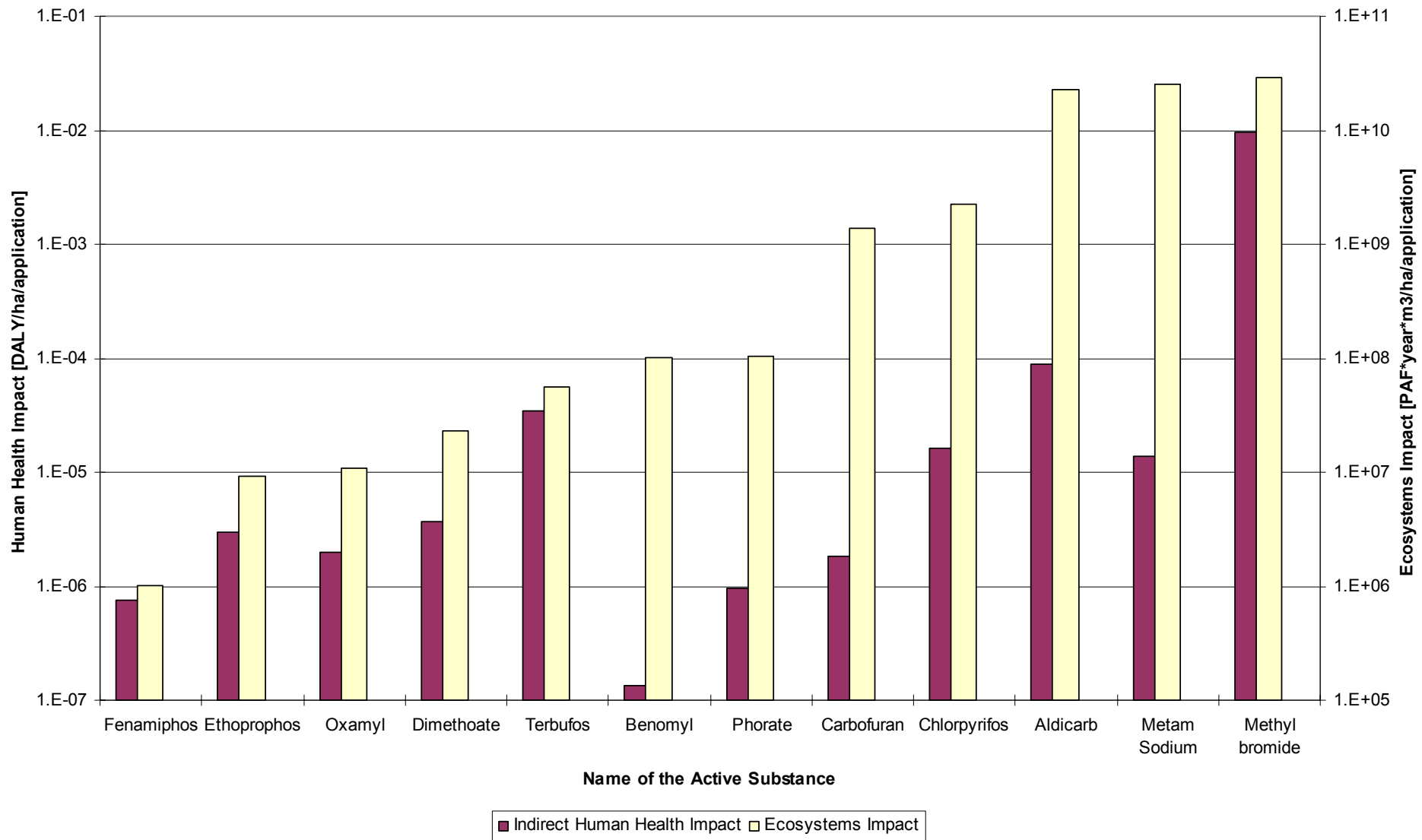
"Indirect" Human Health and Ecosystems Impacts for FUNGICIDES (per HA, for 1 application)



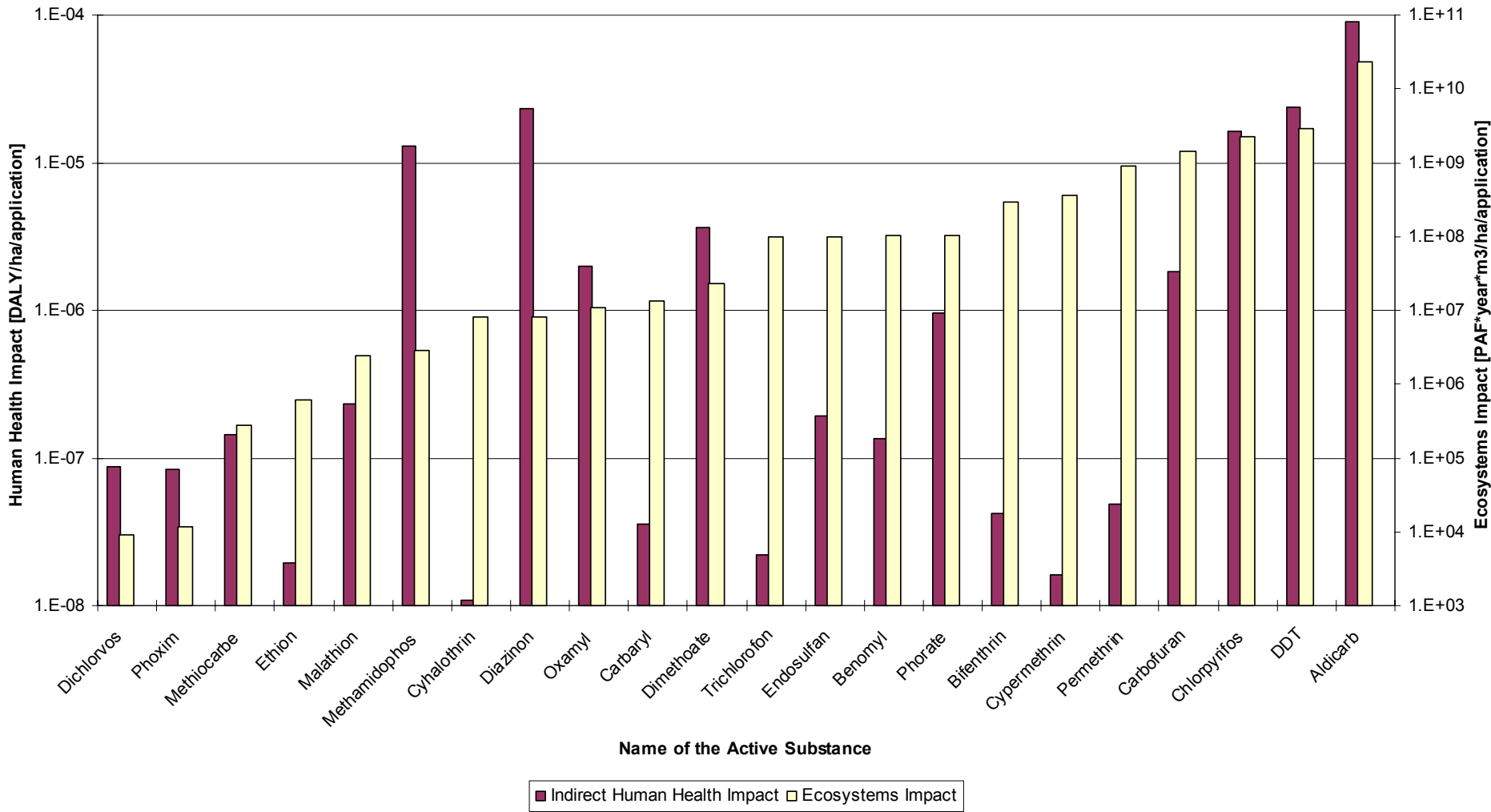
**Annex 34A: "Indirect" Human Health and Ecosystems Impacts for INSECTICIDES (per HA, for 1 application)
(Classed by Ecosystems Impact)**



Annex 35A: Human Health and Ecosystems Impacts for NEMATOCIDES (per HA, for 1 application) (Classed by Ecosystems Impact)



Annex 36A: "Indirect" Human Health and Ecosystems Impacts for ACARICIDES (per HA, for 1 application) (Classed by Ecosystems Impact)



Biocides

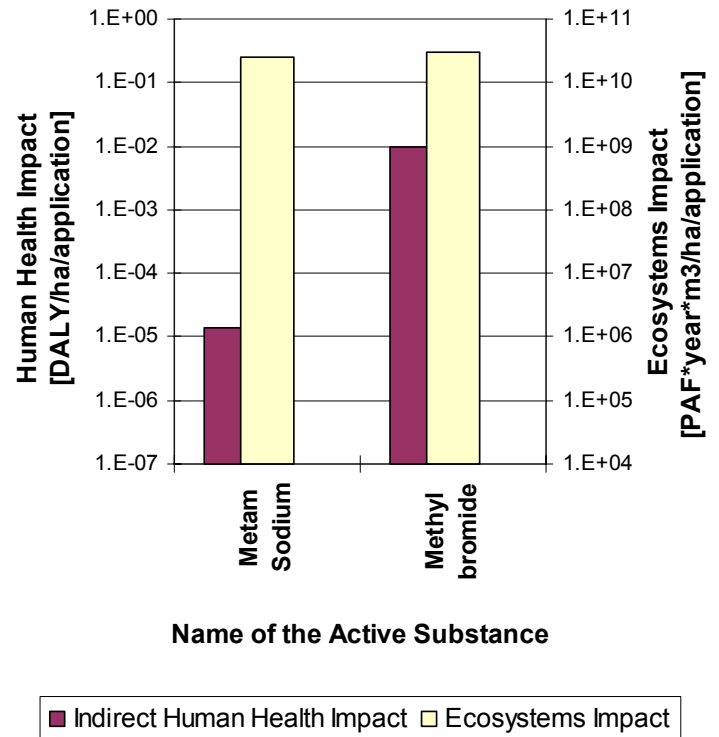
methyl bromide



metam sodium

**! methyl bromide: ozone
destructive gaz
(impact non-included)!**

**"Indirect" Human Health and
Ecosystems Impacts for BIOCIDES
(per HA, for 1 application)**



Observations



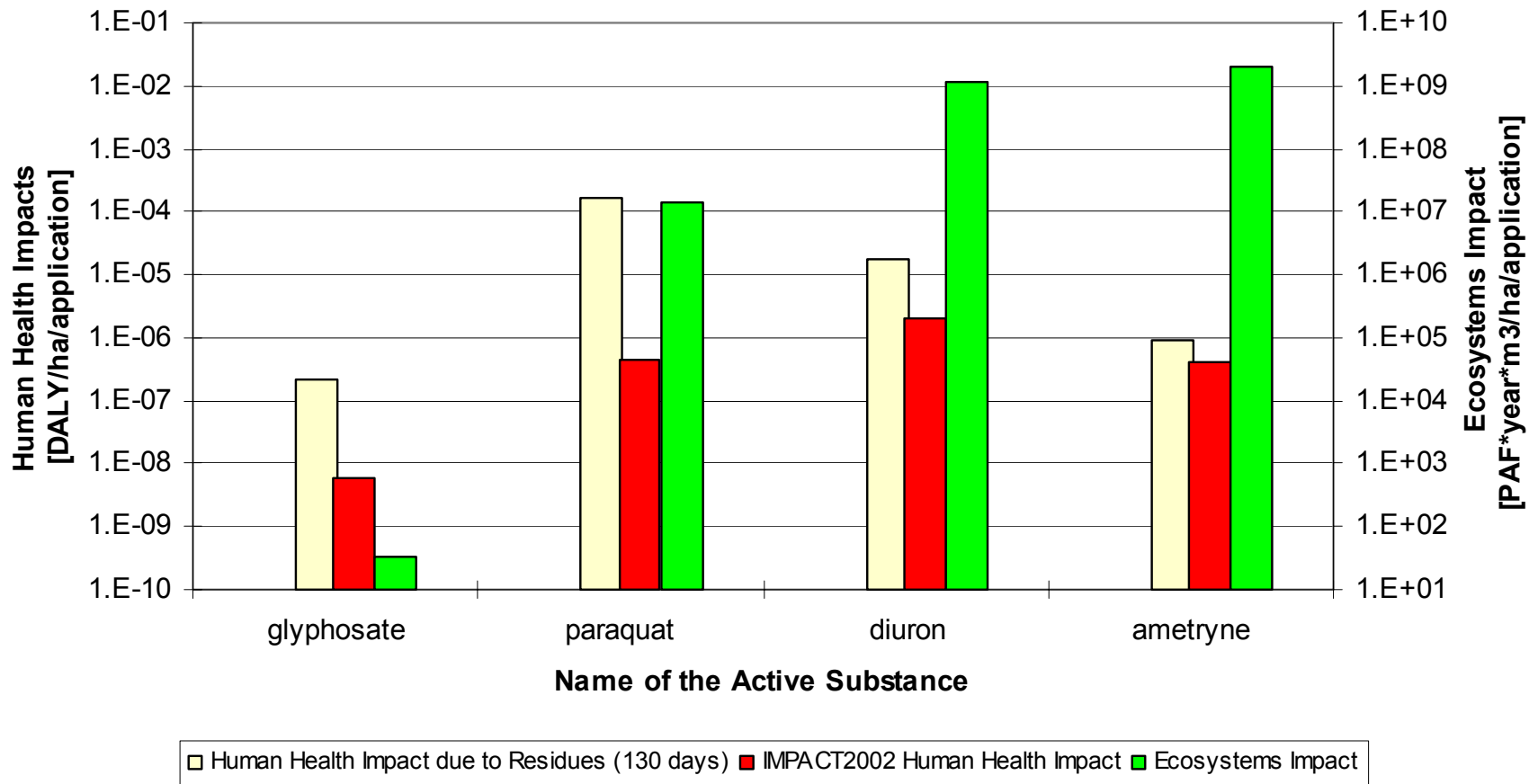
Biocides:

Methyl Bromide ⇔ Metam Sodium (UNEP)
(most harmful for Human Health!!)

Other Classes:

To verify the relation pest/pesticide!

Impacts on Human Health and Ecosystems for Herbicides used in bananas plantations (Impacts per HA, for 1 application)



Conclusions on Substitutions



- Herbicides:

ametryn, diuron, paraquat

<=> glyphosate

- Fungicides:

benomyl, chlorothalonil, mancozeb, (tridemorph)

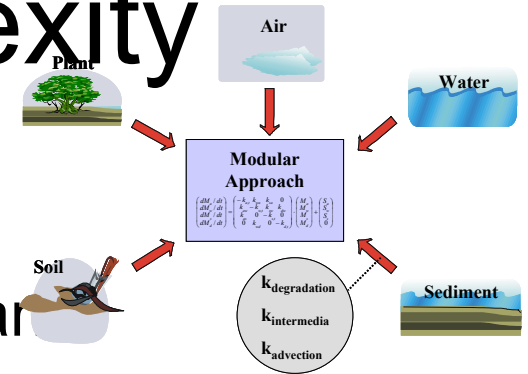
<=> propiconazole

Intake fraction: progression in levels of complexity

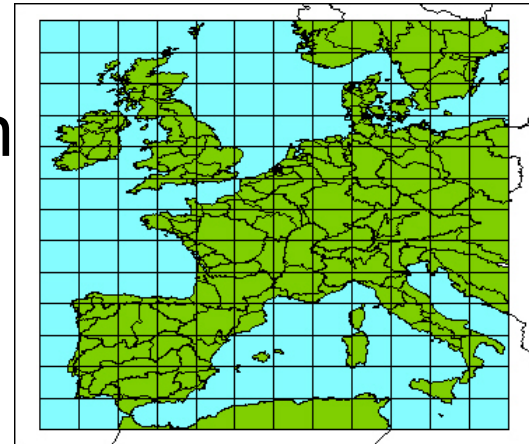
- Tier 1: Steady state model available: "Impact 2002"

- Run independently single media models and couple them in a second step, How ?

- How to address intermittent rain ?



- Tier 2: Spatial differentiation
First model available

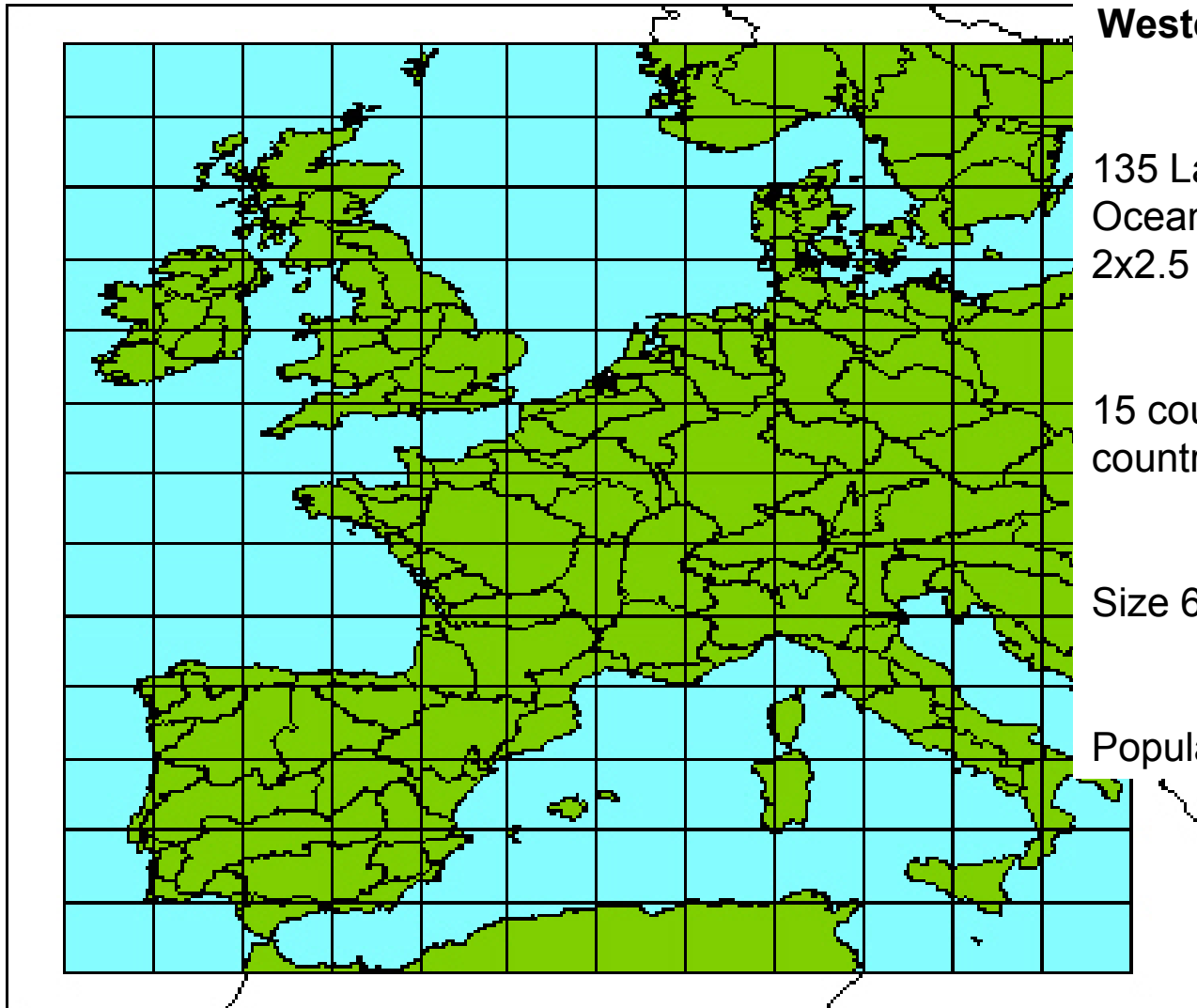


- Tier 3: Dynamic

modelling (e.g plants)

$$M(t) = P \cdot \text{diag}(\exp \lambda_1 t, \dots, \exp \lambda_n t) \cdot P^{-1} \cdot (M(0) + A^{-1}S) - A^{-1}S$$

The spatial model



Western Europe Model:

135 Land zones, 124 Oceanic zones and a 2x2.5 degree air grid

15 countries (entirely), 10 countries (partly)

Size 6'400'000km²

Population: 420 Mio.