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# Strategic Lines for Advances in Terrestrial Ecotoxicology in Tropical Regions

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# Background Considerations

**Differences between temperate and tropical ecotoxicology?**

**1. Ecology: Climate, soils, species composition**

==> Differences in biological test conditions and fate of chemicals

**2. Legal situation: Regulations, institutions, methodology**

==> Different requirements, implementations and methods

**BUT: Similarities should not be overlooked:**

**1. Common start: Pesticide studies in the Sixties/Seventies**

==> e.g.: Koeman et al. (1978): Side-effects of insecticides in Nigeria

**2. Protection goals and general approach should not differ**

==> Aim of ecotoxicological testing: protection of the structure and function of ecosystems via environmental risk assessment (ERA)

# Temperate vs. Tropical Regions I

**Focal region:** **The tropics**

► Area between the Tropic of Cancer and the Tropic of Capricorn, mainly characterized by mean annual temperature > 20°C

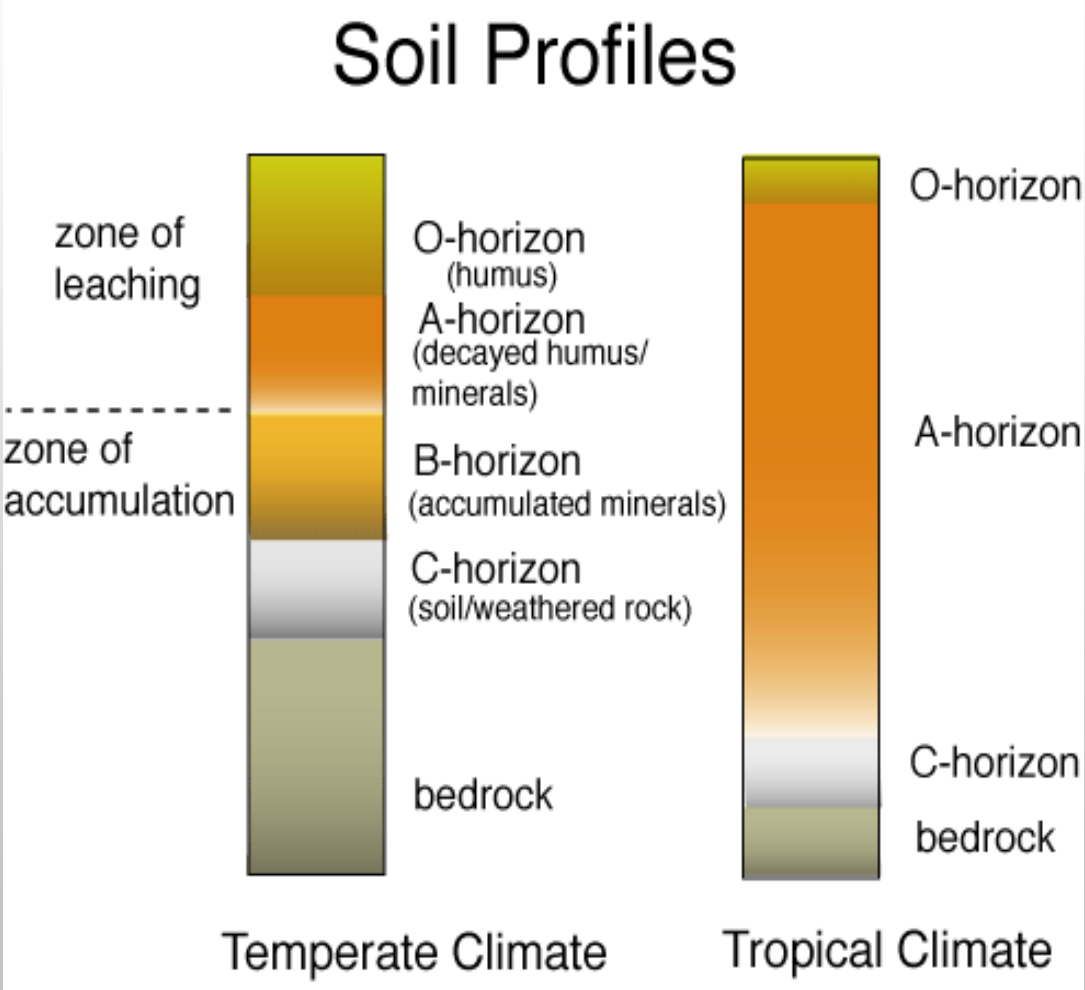
# Temperate vs. Tropical Regions II

**Focal compartment: Soil**

Temperate and tropical soils differ in their properties:

==> e.g. the profile

**On average**, tropical soils contain less nutrients, have a smaller litter layer, a lower pH, and a more clayey texture than temperate soils.



# Temperate vs. Tropical Regions III

**Different ecology ==> different soil organism communities:**

Dominant in **temperate soils**: Collembola, Enchytraeidae, Earthworms


Dominant in **tropical soils:** Isopoda, Termites, Earthworms

# Temperate vs. Tropical Regions IV

**Different ecological conditions cause different chemical fate:**

Soil $DT_{50}$ values of pesticides in the Brazilian Amazon (Roembke et al. 2008)

| Active ingredient | Use type | DT50 temp | Source | DT50 trop | Source |
|---|---|---|---|---|---|
| Abamectin | Insect. | **56** | Halley et al. 1993 | **28** | Van den Bosch et al. 2005 |
| Deltamethrin | Insect. | **35** | Laabs et al. 2002b | **12.4** | Laabs et al. 2002a ; 2002b |
| Glyphosate | Herb. | **32** | Giesy et al. 2000 | **27.7** | de Andrea et al. 2003 |
| Indoxacarb | Insect. | **117** | EU 2005 | **58.5** | - |
| Lambda-cyhalothrin | Insect. | **35.5** | Laabs et al. 2002b; Van den Bosch et al. 2005 | **8.8** | Laabs et al. 2002a; Reichenberger et al. 2002 |
| Linuron | Herb. | **62.9** | Beyer and Matthies 2001; | **31.5** | - |
| Malathion | Insect. | **10** | Van den Bosch et al. 2005 | **5.0** | - |
| Mancozeb | Fung. | **4.9** | Van den Bosch et al. 2005 | **2.5** | - |
| Metamidophos | Insect. | **2.0** | Beyer and Matthies 2001 | **2.6** | Van den Bosch et al. 2005 |
| Parathion | Insect | **49** | Van den Bosch et al. 2005 | **22.5** | Sattar 1990 |

**Different by a Factor of 2!**

# Temperate vs. Tropical Regions V

**Temperate regions:**

Complex and detailed regulatory requirements for soil ecotoxicology do exist everywhere (except the USA) and their local implementation is secured.

**Tropical regions:**

Legal requirements do often exist but local implementation is regularly lacking.

➔ **Improvement is urgently needed!**

# Intermediate Summary: The Way Forward

**There is no scientific reason why the strategic lines for ecotoxicology should differ in the different regions.**

**However, some issues must be addressed in order to close the gap between actual ecotoxicology in temperate and tropical regions:**

1. Legal requirements have to be implemented in practice.
2. Scientific ecotoxicological institutions have to be promoted.
3. Research on basic ecology has to be expanded.
4. Test methods have to be adapted or developed.

**These topics will be discussed in the following.**

# Legal Requirements and Implementation

**Statement as a basis for further discussions:**

**This issue is beyond the possibilities of most scientists**.

However**, citizens** of any country in which ecotoxicological effects on the environment are possible, **should support actions for**:

- **Regulation of chemicals**, including a formalized and transparent risk assessment, in any part of their life-cycle.
- **Training of people** (e.g. farmers) regarding use and disposal of chemicals with care. Especially important for pesticides, since they are the only chemicals being in the environment intentionally.
- **Strict enforcement of rules** such as avoiding banned chemicals.

# Promotion of Ecotoxicological Institutions

**In most parts of the temperate regions, ecotoxicological research and application is divided between three groups:**

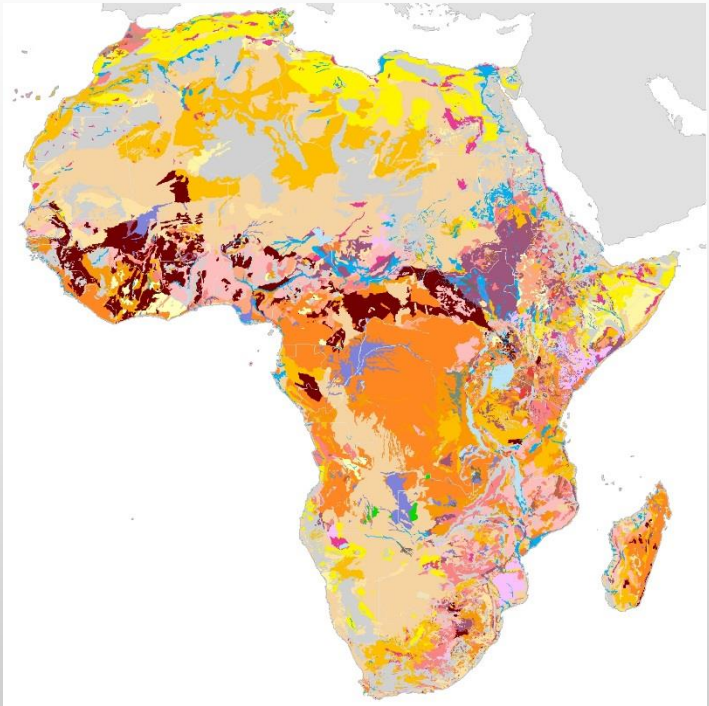
- ➔ **Industry:** They know their products best but are rarely proactive in ecotoxicological research. However, they follow regulations (if they exist – and if they are clear and reliable).
- ➔ **Universities:** 30 years ago, they did not consider ecotoxicology as a science of its own – but fortunately this has changed. Especially regarding training of students is extremely important.
- ➔ **Governmental institutions:** They play a double role:
  - collecting and preparing scientific information
  - acting as regulators, evaluating the outcome of an ERA.

**The latter two have to be promoted – but must be kept independent.**

# Research on Stress Ecology I

**Abiotic information needed for the evaluation of stress on ecosystems:**

- Mapping of soil types and properties, on different scales.
- Influence of climatic factors of soil development and degradation.
- Distribution of land use activities in time and space,.
- Effects of natural stressors (e.g. climate change).
- Influence of abiotic factors on chemical degradation as well as bioavailability.



Pedological map of Africa
Source: European Union, 2012

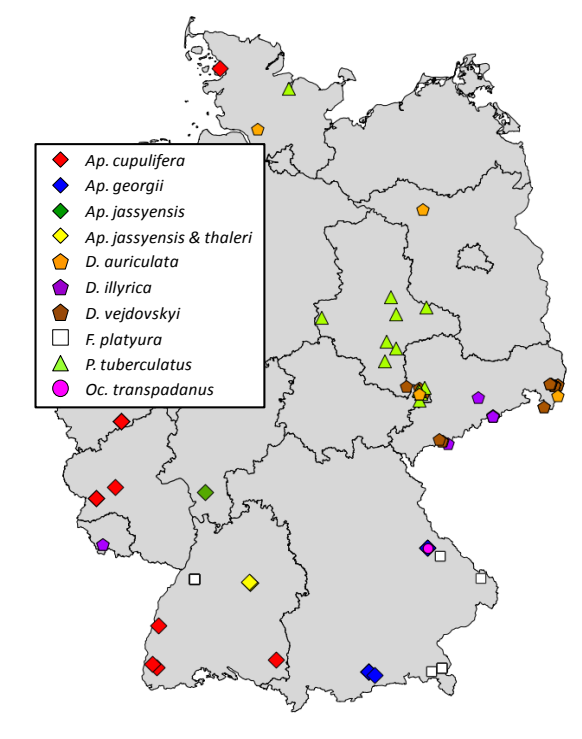
# Research on Stress Ecology II

**Biotic data needed for the evaluation of stress on ecosystems:**

Overview on species/group number, biomass, and the ecological roles of soil organisms in the main soil types, preferably as a map.

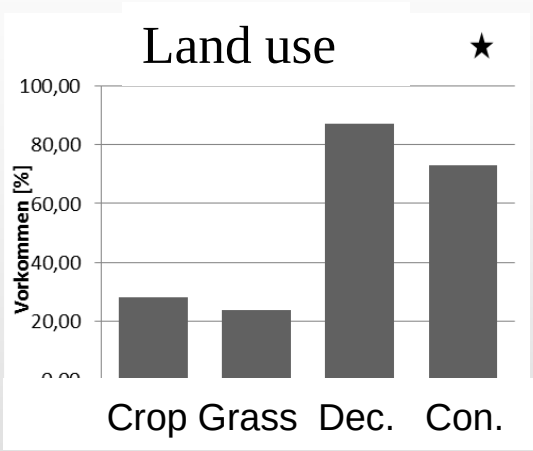
Using the **trait-approach** in order to simplify the evaluation of effects on communities, including the extent of recovery.

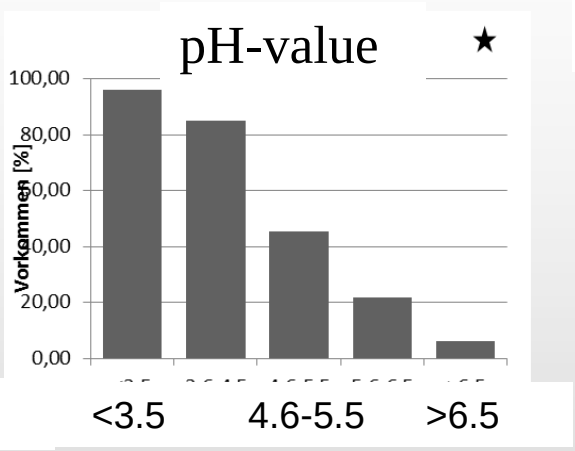
Identifying the **Normal Operating Range (NOR)** for each species (or group),
➔ ecological information is used as a basis for a **reference system**.

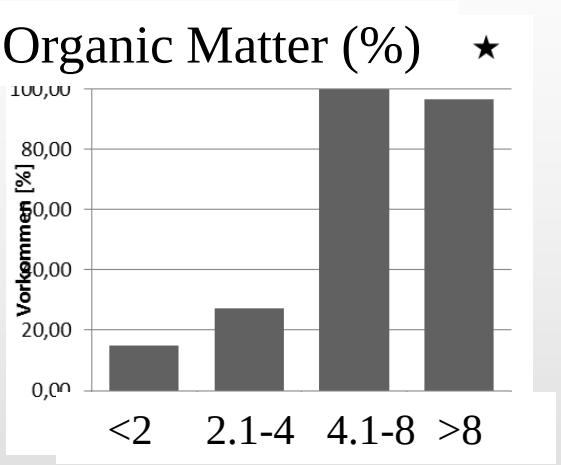



Findings of rare species of earthworms in Germany
Lehmitz et al. (2014)

# Research on Stress Ecology III

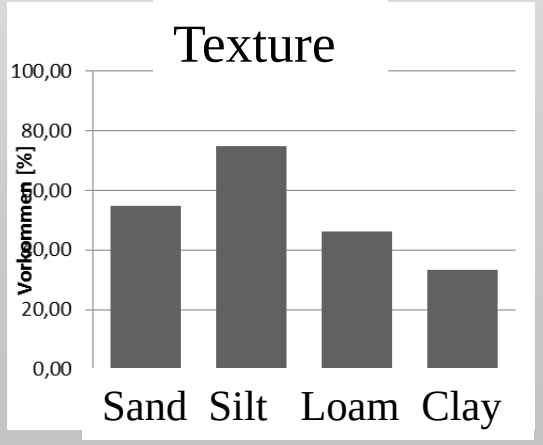



**Ecological profile: *Cognettia sphagnetorum***

- In acid soils often highly dominant;
- (Yet) only **enchytraeid** species which is „Ecosystem-Engineer“ (Lavelle et al. 2005)
- Typical litter-dweller



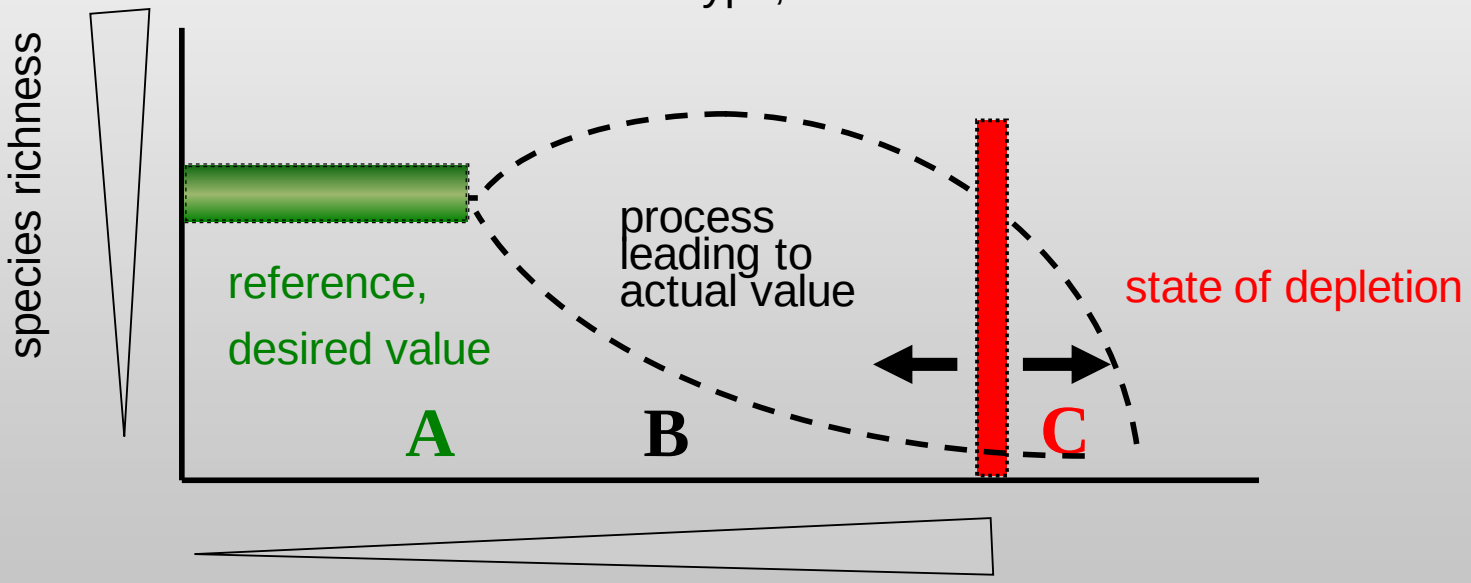
# Research on Stress Ecology IV

**When is a deviation from the reference at one site a „problem“?**

**reference (state of preservation A-C)**

depending on edge effect, structural diversity, soil type, etc.

**limit of not acceptable implications = minimum standard (to be defined)**

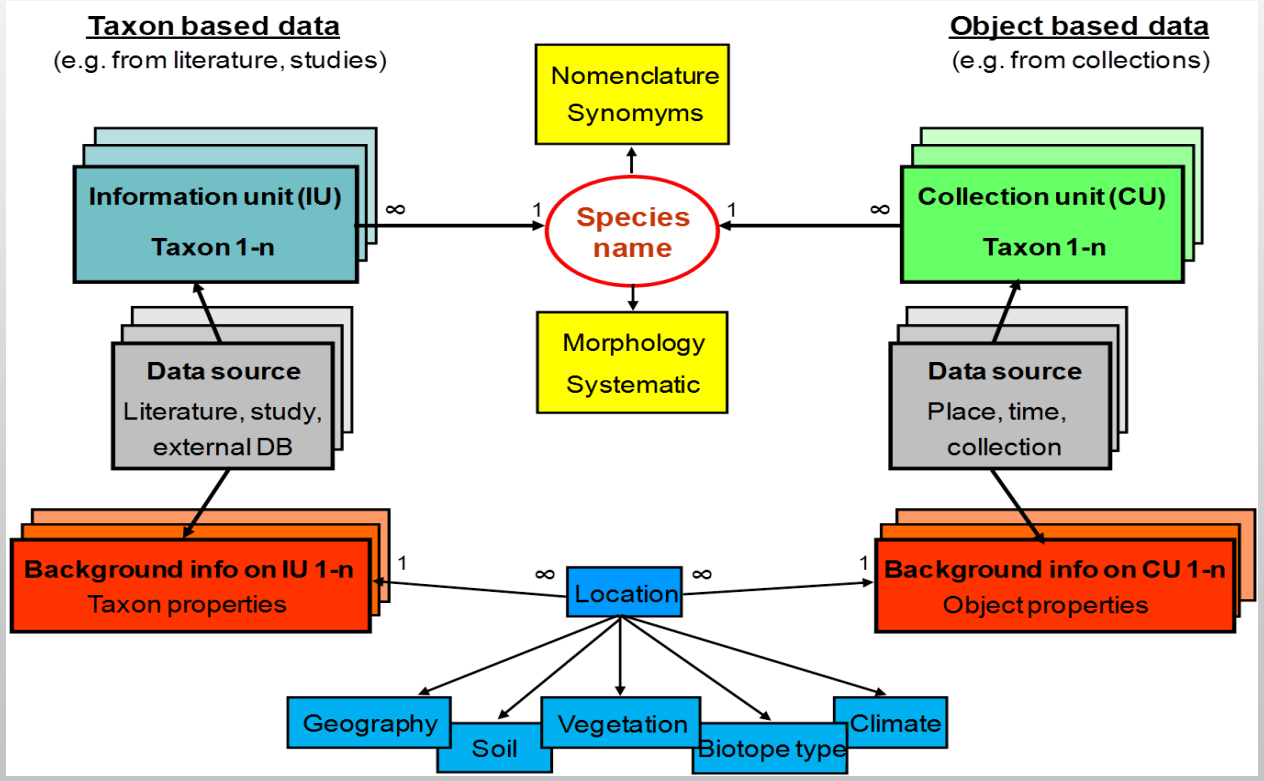



system stress → change of diversity → not acceptable disturbance

# Research on Stress Ecology V

In order to optimize ecological information for the evaluation of the effects of stress on soil organisms, **all data should be available freely**.

One example is the German **Edaphobase**, Located at the Museum of Görlitz.



# Adaptation of Methods for the Tropics I.

**Adaptation of existing test methods: two examples**

**ISO (1993) 11268-1 + 2: Effects of pollutants on earthworms.**

An Annex of these guidelines contains modifications for tropical regions:

- Temperature: 20 +/- 2 °C ➔ 26 – 28 °C
- Test substrate: OECD artificial soil ➔ Tropical artificial soil

**So far, there is NO international guideline specifically for the tropics.**

==> **ISO:** Other guidelines will be modified accordingly, but :

Is TAS suitable for other test species as well?

➔ **OECD**: No changes made , but discussions are on-going

➔ **National standardization:** No overview.

But: Change has been made by ABNT (e.g. 15537 (2007)).

# Adaptation of Methods for the Tropics II

**Which species are relevant as test organisms for tropical soils?**

**Earthworms:**

***Eisenia andrei / E. fetida*** are found eveywhere.

Other tropical species have been proposed:

- *Eudrilus eugeniae* (epigeic): Africa
- *Perionyx excavatus* (epigeic): Asia
- *Pontoscolex corethrurus* (endogeic): Brazil

All of them are (+/-) peregrine or invasive…..

**Enchytraeidae:**

***E. crypticus*** is (probably) a tropical species

Alternatively, *E. dudichi* is possible.

# Adaptation of Methods for the Tropics III

**Due to the higher structural and ecological relevance of arthropods in the tropics, more such species should be used as test organisms:**

**Collembola:**

***F. candida*** could be replaced by the tropical (?) species *Sinella curviseta*

**Isopoda:**

*P. pruinosus* is a suitable for the tropics.

But, probably a mix of several cryptic species.

**Diplopoda:**

Highly relevant, but species not yet clear.

e.g. *T. corallinus*

# Adaptation of Methods for the Tropics IV

**As in temperate regions, the relevance of higher tier tests will in increase in the future in the Tropics as well.**

**Laboratory multi-species tests, especially with micro-arthropods:**

- Example: the temperate SMS test; not known from Tropics

**Microcosms or terrestrial model ecosystems:**

- Examples from Indonesia and Brazil known, but not yet required or standardized

**Field tests:**

With structural and functional Endpoints, few tropical examples.

# Adaptation of Methods for the Tropics V

**Several issues beyond individuals methods have not yet discussed:**

- **Bioavailability:** Are there differences regarding exposure and/or physiologies between the two regions?
- **Kinetics:** Not yet implemented in temperate regions but potentially important everywhere (incl. internal processes).
- **Ecotoxicogenomics**: different “Genomics” tools proposed trying to link gene expression and ecologically relevant endpoints but use in regulatory ecotox so far.
- **Retrospective higher-tier approaches:** e.g. the TRIAD. Currently being standardized by ISO. Relevant for Tropics.

# Summary of Strategic Lines I

**Starting Point:** In temperate and tropical soil ecotoxicology there is the same theoretical and practical approach.

➔ the strategic lines to be followed should also be similar.

**BUT: same basic deficiencies have to be improved:**

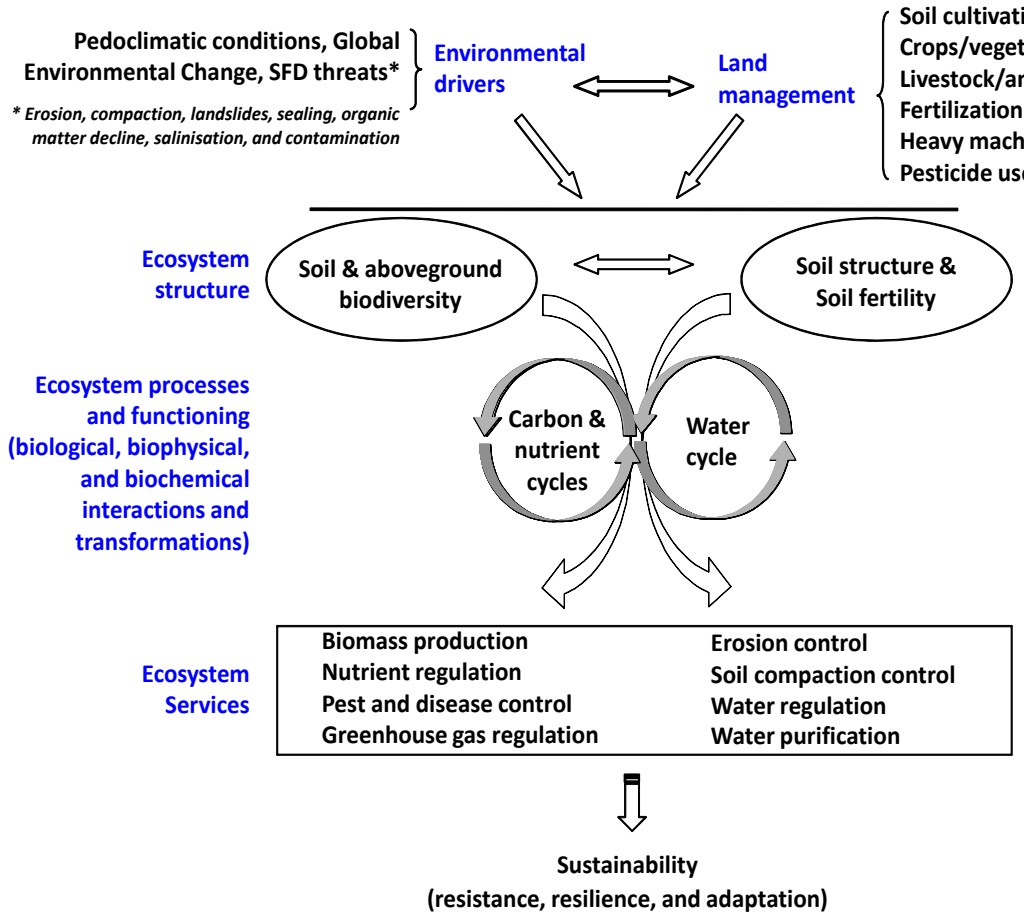
- **Regulations** and legal requirements and, in particular, their **implementation** have to be evaluated and improved.
- **Ecotoxicological institutions,** i.e. those involved in research and training (= universities) and risk assessment regulations (= government) need promotion.
- **Basic ecological research** on abiotic and biotic properties of the environment has to be expanded.

# Summary of Strategic Lines II

**On a methodological level, the following actions are necessary:**

- **Adaptation of existing (OECD, ISO) methods,** in particular regarding the selection of species, soil type and temperature.
- **Development of new tropical tests**, using the same criteria as in temperate regions. Surely, a battery is needed covering taxonomic, physiological and especially ecological differences.
- **Set-up of higher-tier tests**, representing ecological reality and covering both structural and functional endpoints.
- **Improve the environmental risk assessment**, by implementing bioavailability or by evaluating sites by using the TRIAD-approach.i

# Outlook: Ecosystem Services….




***Relationships between soil biodiversity, ecosystem functioning and ecosystem services (Brussaard et al., 2007; Faber et al. 2014)***

# Acknowledgements

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