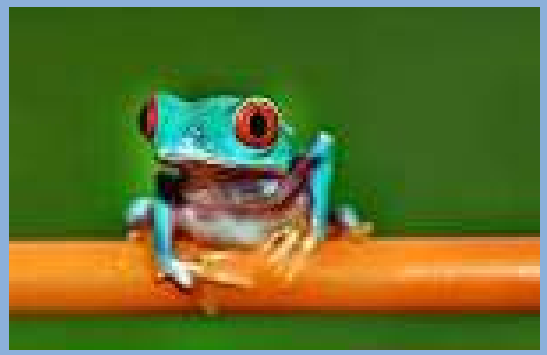
IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE



International Union of Radioecology

Ecological impact of ionising radiation, an endpoint issue ?

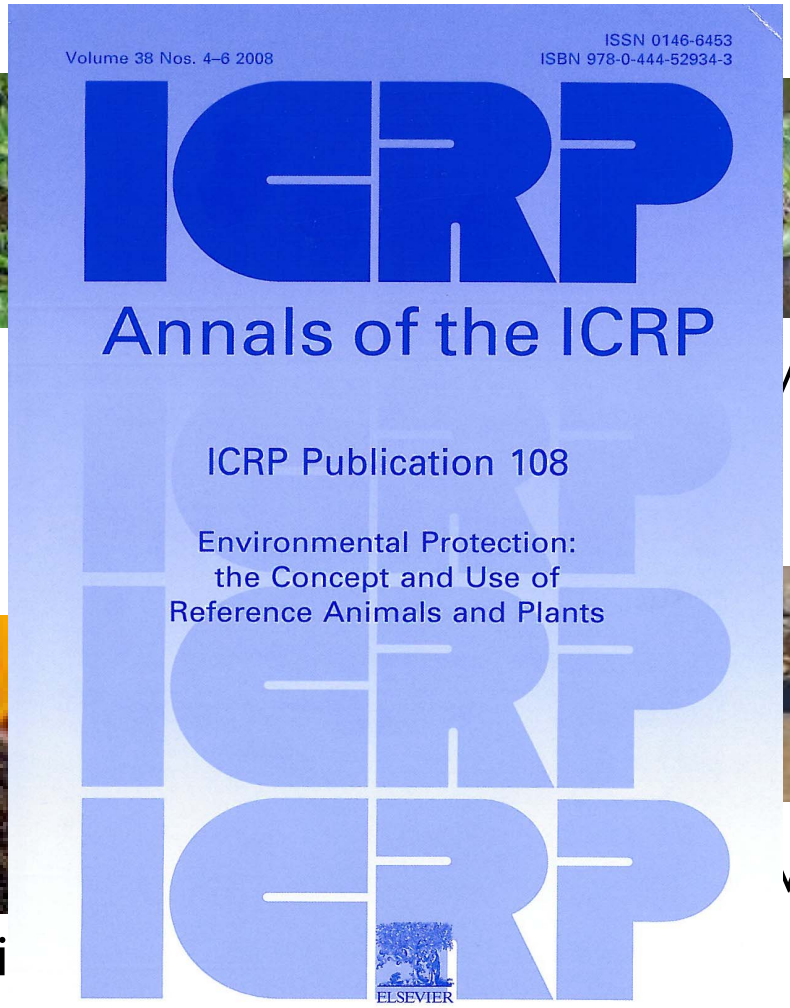
F. Bréchignac, C. Bradshaw, S. Carroll, A. Jaworska, L. Kapustka, L. Monte, D. Oughton, S. Fuma, L. Hakanson, I. Kawaguchi, T. Sazykina, P. Strand

EU Scientific Seminar 2012
Protection of the Environment

European Commission, 20 November 2012, Luxembourg

Today's concept: « reference organisms » or RAPs

Terrestri

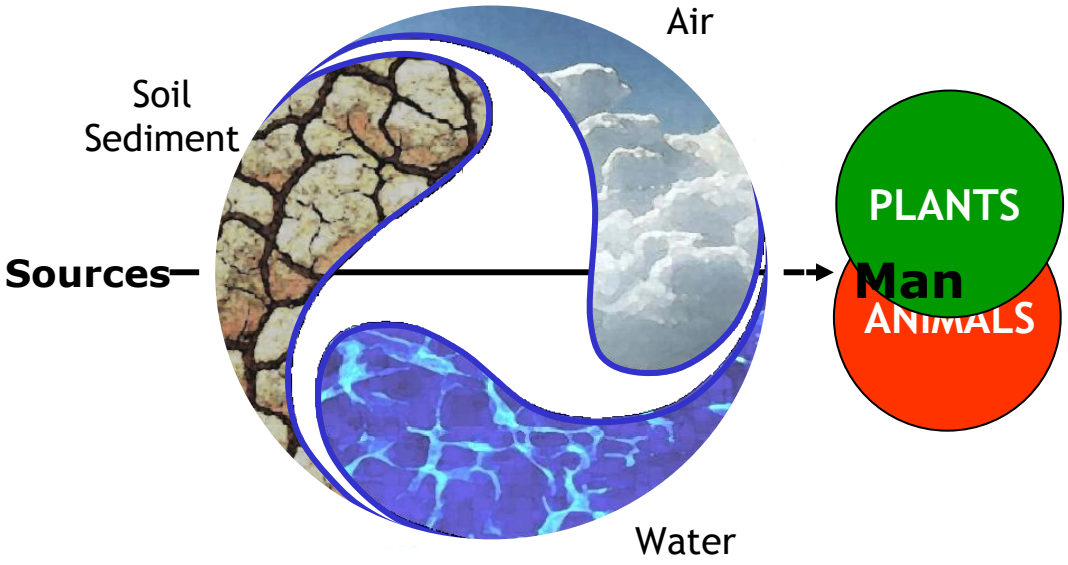


water

vater

IRSN

« Reference organism approach »: biocentric



Environment

- Pristine nature (the wilderness and its biota, fauna and flora)
- Radioactivity effects on wild animals and plants
- Animals and plants as targets

Linear Transfers to biota

But also effects

Radioecology to support man and environment radioprotection

Today's concept: « reference organisms » or RAPs

- Typical, accessible, documented, various sizes and life cycles, measurable dose-effect
- Generic virtual entities to serve as points of comparison to assess exposure and effects
- Devices to relate *exposure to dose* & *dose to effect* for some types of animals and plants
- Basis for *comparison*, for *advice*, for aiding *decision making* under different circumstances

… all considered at individual organism level

Conceptual method entirely built upon individual organisms responses

RN distribution (actual/modelled)

EXPOSURE

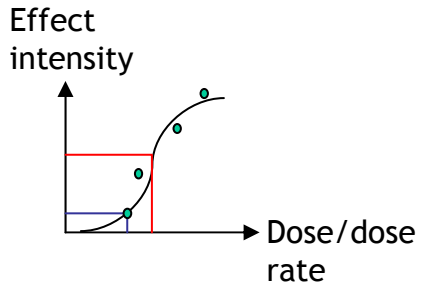
CR, TF

Dosimetry

Dose or dose rate ($Gy.d^{-1}$)

- For each ref. org./RAP
- For each radionuclide

EFFECT



For effect endpoints IN INDIVIDUALS

Littérature compilation

SCALE OF RISK (DCRLs)

Most knowledge incorporated in the system comes from isolated organisms tested in ideal experimental conditions

Objectives of protection / targets of protection: an issue of endpoints consideration

Endpoints related to **Individual organisms**

- Early mobidity
- Mortality
- Reproductive success
- Chromosome damage

Endangered species
Protection of biodiversity
Pollution control
Nature conservation

Sectorial objectives (past trend)

Populations/communities

Structure and functions of ecosystems

Integrated objectives (today's trend)

Objectives of protection / targets of protection: an issue of endpoints consideration

Endpoints related to **Individual organisms**

- Early mobidity
- Mortality
- Reproductive success
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Biological impact

Endangered species
Protection of biodiversity
Pollution control
Nature conservation

Sectorial objectives (past trend)

Ecosystem approach ?

Need for Endpoints related to

POPULATIONS and ECOSYSTEMS

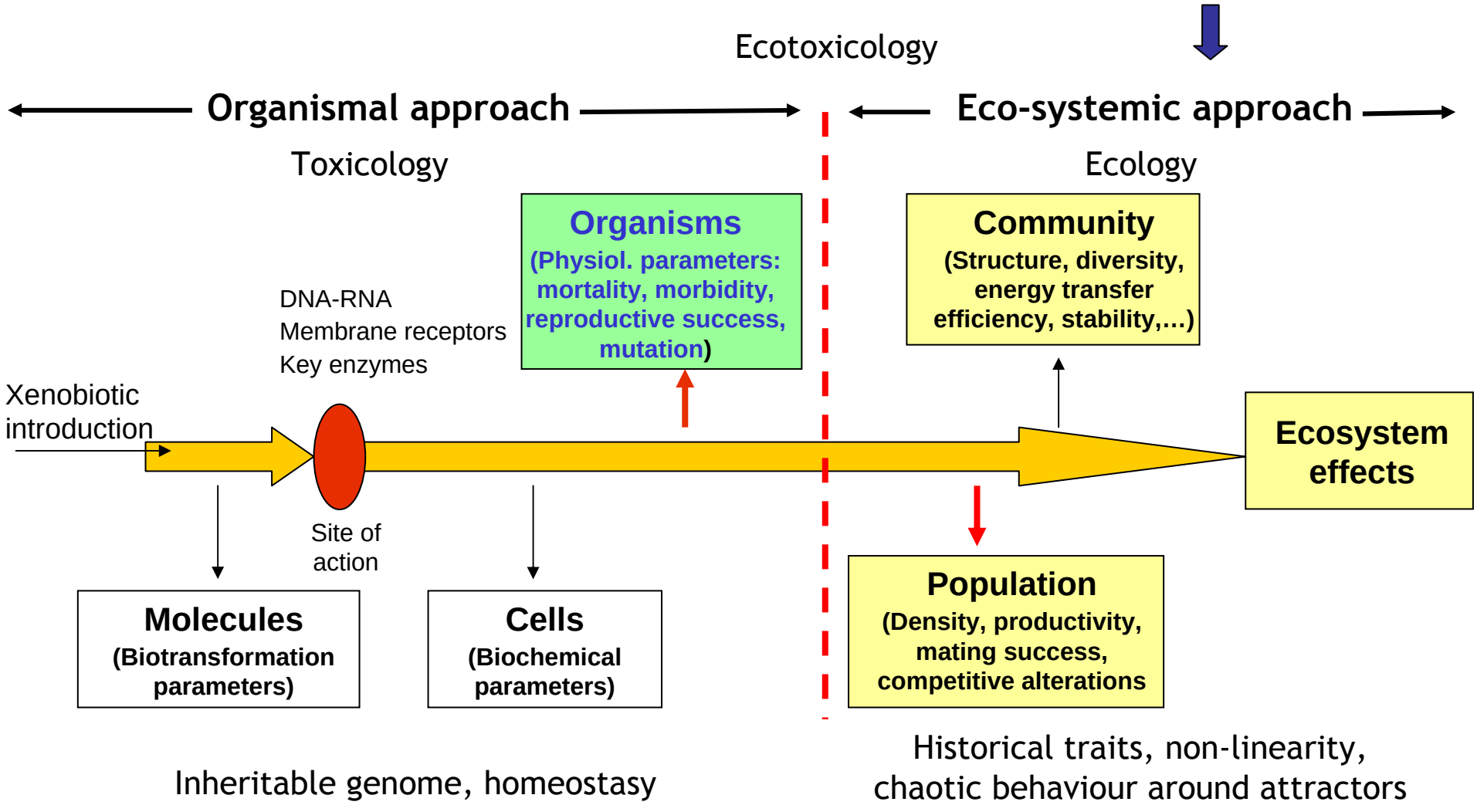
Ecological impact

Populations/communities

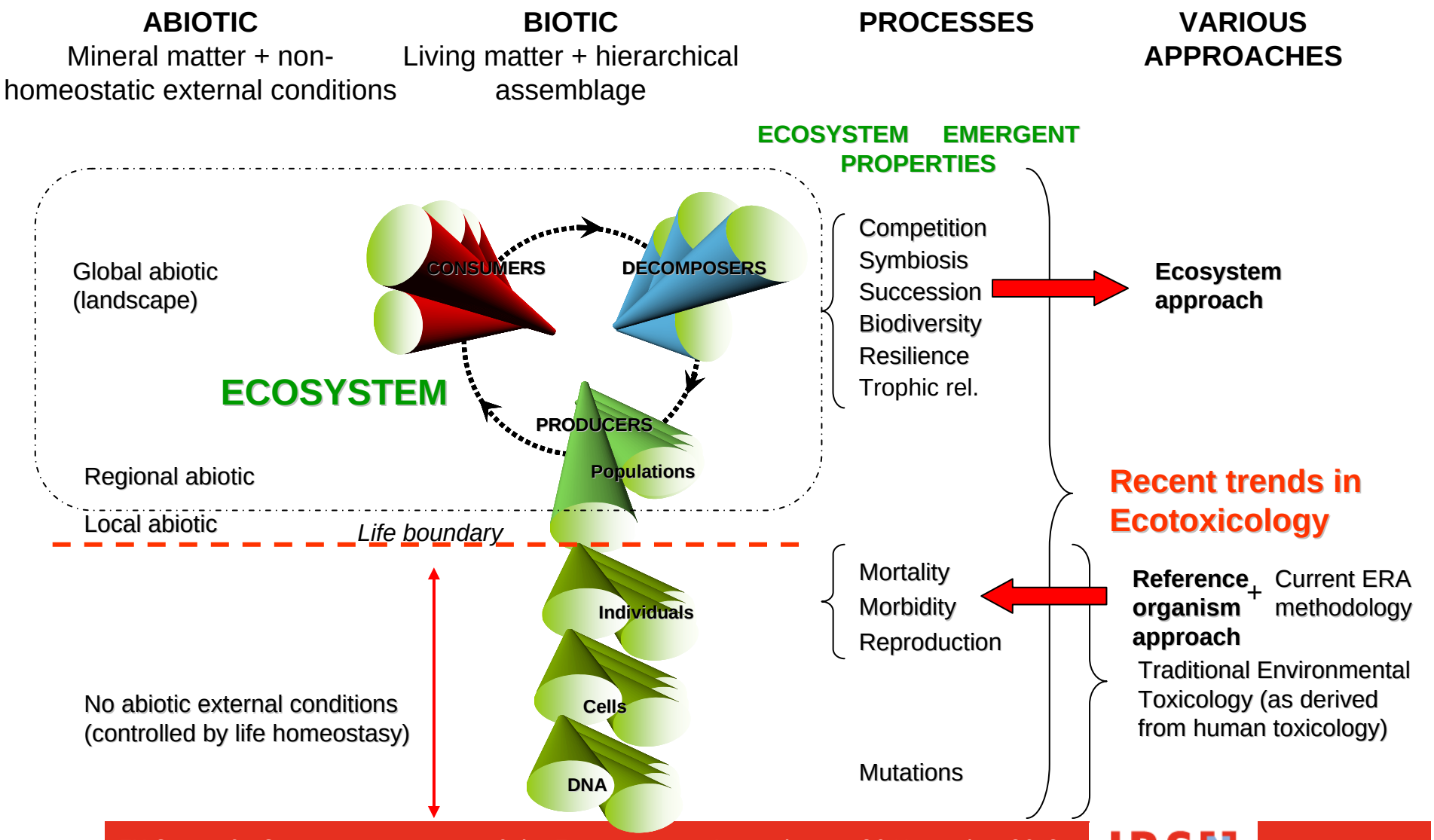
Structure and functions of ecosystems

Integrated objectives (today's trend)

Biocentric approach partially meets EP objectives



Reference organism / ecosystem approach



Biocentric approach is mismatched with environment protection general objectives

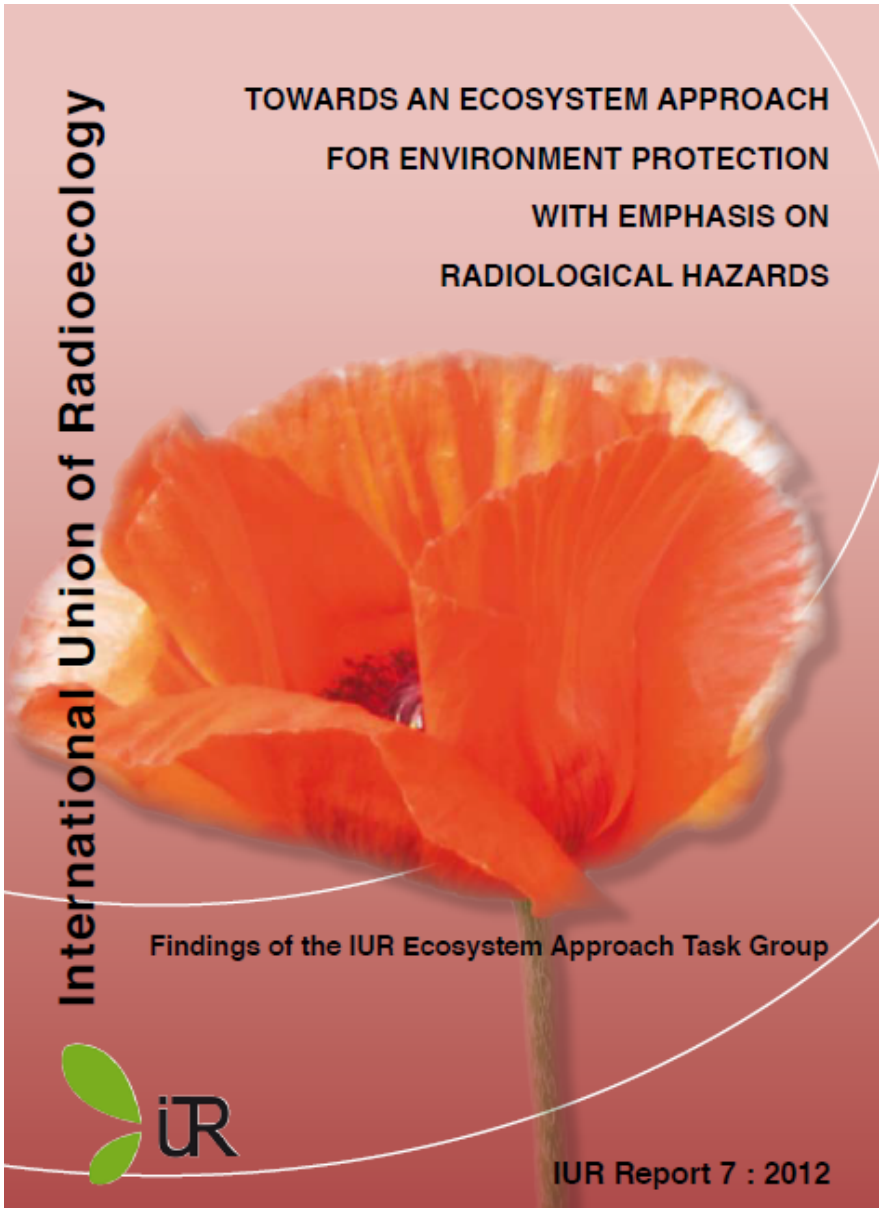
« Reference organism approach » is totally grounded on **individual responses** to radiation, with no consideration of higher levels of organisation.

- Methodology is **mismatched** with regard to the objectives of protection it is meant to support (protection of populations and beyond… not only individuals)

- Methodology ignores **interactions between species** which govern impacts at system level

- Methodology cannot account for **ecosystem-level effects** :
  - indirect effects, « cascade effects»
  - trans-generation propagation of effects
  - propagation from individuals up to populations and ecosystem

Tomorrow: ecosystem approach



IUR Task Group gathering proficiencies beyond the only field of radiation

Report now published (free distribution to all members, annual fee cleared)

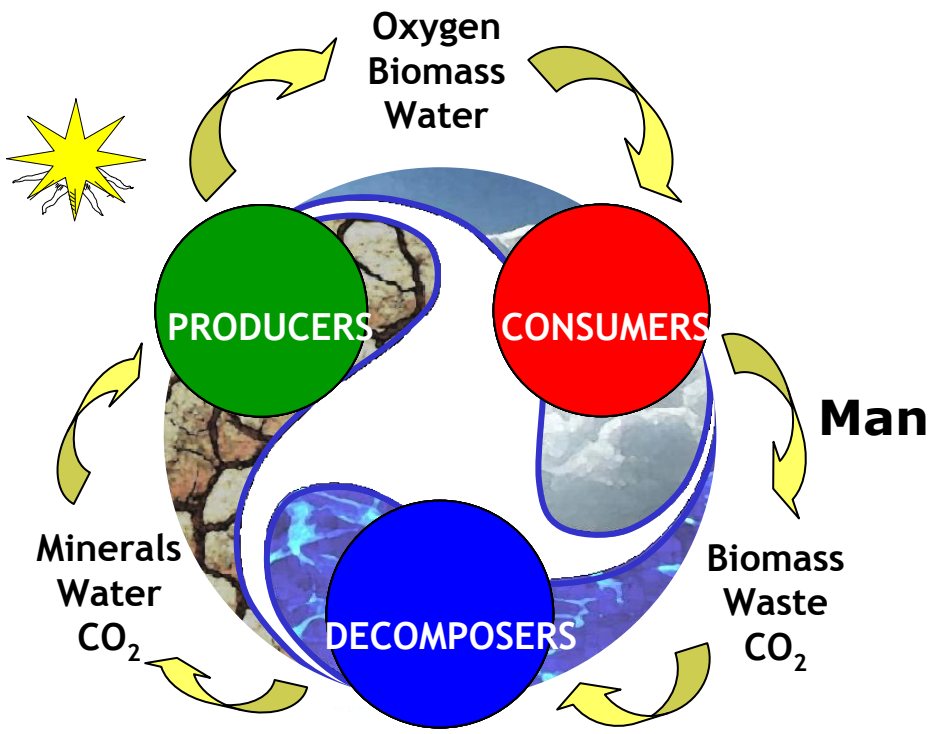
Order at: www.iur-uir.org

The « ecosystem approach » is applied in a number of domains, outside the radiation field

- **Recommended by users and environmental risk managers**
  - Fisheries (FAO, 2003; NOAA, 2003)
  - Marine coasts (English nature, 2004)
  - Forestry (IUCN, 2004)

- **Recommended within international agreements and conventions**
  - Convention on Biological Diversity (UNEP-CBD, 2004)
  - Water Framework Directive (EC, 2000)
  - OSPAR (Bergen statement, sept 2010)
  - UNEP(in relation to IAEA revision of IBSS, June 2010)

What is the « ecosystem approach » ?
Towards an ecocentric vision



Environment including man

- **Ecosystem** = biotope + biocenose

  - **Services** (waste recycling, provision of ressources, …)

  - **Life support** (water recycling, air bioregeneration, biomass production, …)

Ecosystem approach accounts for indirect effects (ex: response to UV irradiation)

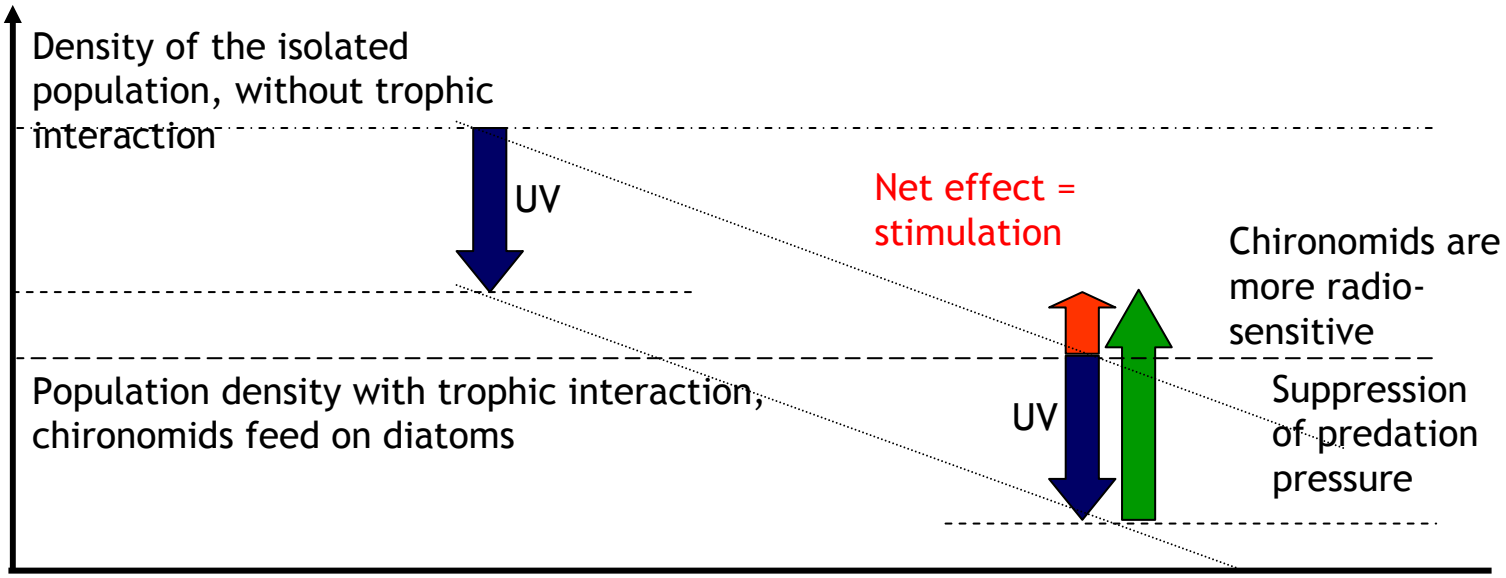
Diatoms population density

UV irradiation of an isolated population of diatoms

UV irradiation of an ecological system diatoms-chironomids in trophic interaction

reduction

stimulation



M.L. Bothwell, et al. (1994) Ecosystem response to solar ultraviolet-B radiation: Influence of trophic level interaction. Science 265; 97-100

Ecosystem approach accounts for higher levels of organisation…

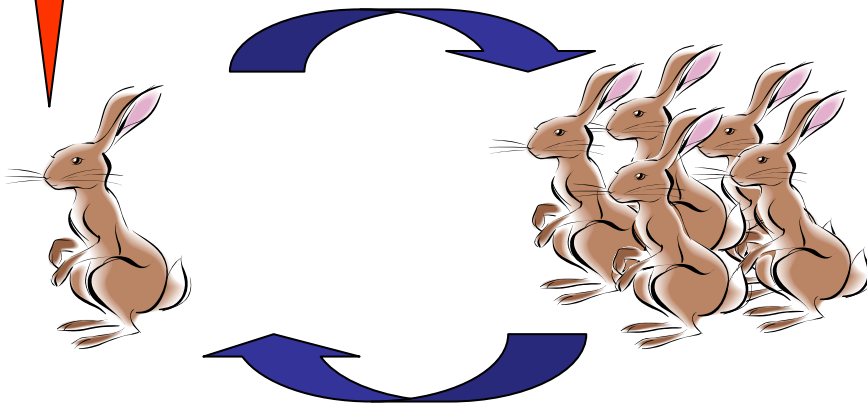
Ref. organism approach :

Toxicologial data from individual organisms

- Individual mortality
- Fertility
- Fecondity
- Mutations

Ecosytem approach :

- Other endpoints…
- more integrated…



Toxicology

Ecology

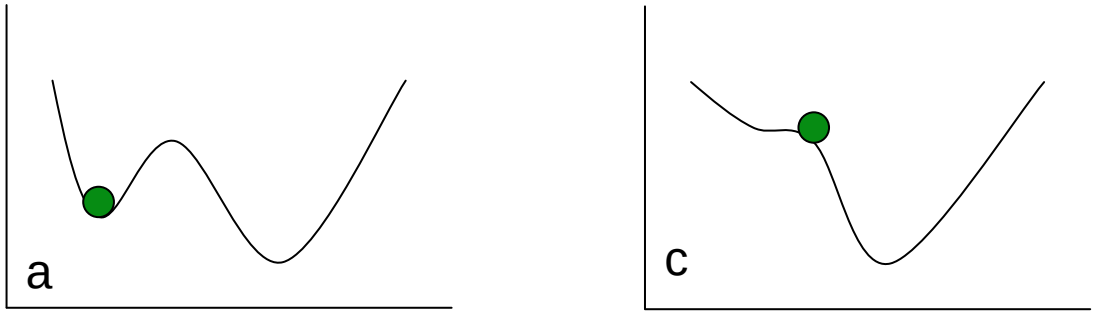
Ecotoxicology

Adapted from Constanza *et al.*, 1997; Curtis, 2004

Ecosystem approach should account for the concept of resilience

Resilience:

- Ecosystem capacity to « buffer » a perturbation pressure without apparent damage
- Emergent property linked to complexity



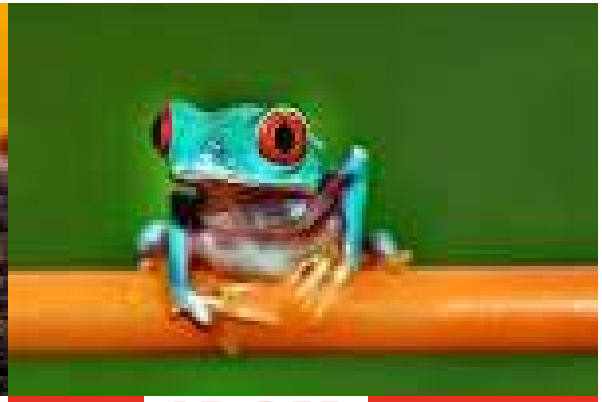
Highly resilient ecosystem Poorly resilient ecosyst.

Different critical (maximal) levels of perturbation without effect ?

Recommendations for radiation protection

- **Develop more integrated and functional endpoints to expand beyond the organism-level**
- Incorporate more **ecological contextualisation** in the Reference organism approach
- Promote **overall consistency** across the broad spectrum of ecological research and environmental management
- Promote the **dialogue** between environmental assessors and environmental managers





What kind of endpoints to support an ecosystem approach ?

- Endpoints related to ecosystem structure:
  - Biotic indexes (trophic architecture, complexity)
  - Biodiversity indexes (genetic structure)
- Endpoints related to ecosystem functioning:
  - Primary productivity, respiration
  - Populations biomass
  - Carbon, nitrogen cycling
  - Energy cycling

Research priorities identified

- Study of impacts at ecosystem level (top-down): interactions between populations, sensitivity to population changes, …

- Improve studies at individual organisms/species level (bottom-up) by focusing more on ecologically relevant effects: functional groups/taxa missing, differences in radiosensitivity,…

- Promote field studies and cross-cutting disciplines and approaches: Chernobyl, mines, Fukushima, gradient instead of « control » studies, gathering collaboration from geneticists, molecular biologists, systems and landscape ecologists,…