WHAT CONCEPTUAL APPROACH FOR ASSESSING ECOLOGICAL IMPACT OF RADIATION

Biocentric versus ecocentric view

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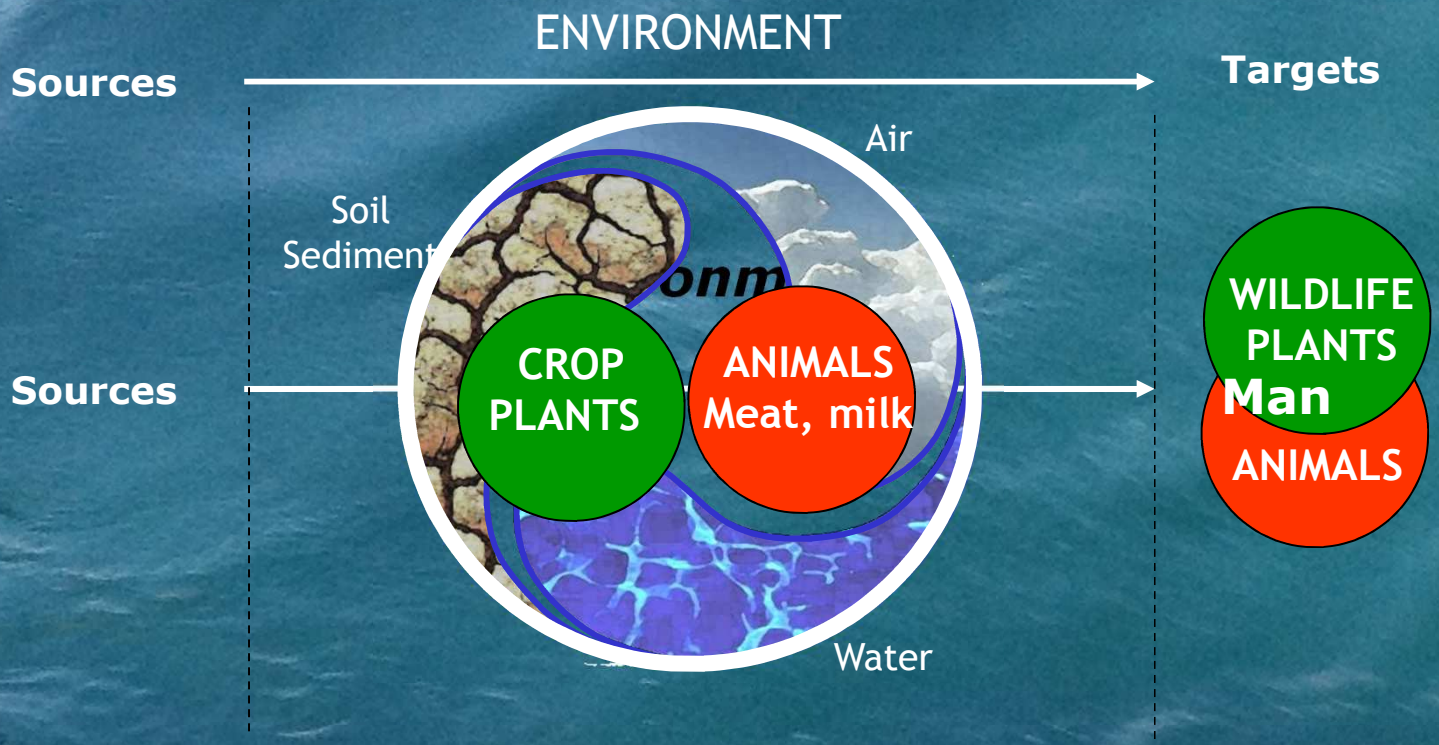
Today's radiation protection framework for environment protection

- Legislation, existing or upcoming, requires environment protection measures for all stressors, with no exception for radioactivity
- Will to be able to demonstrate that the environment is indeed protected
- Reconsidering the anthropocentric ICRP paradigm « Human protection indirectly ensures adequate protection of the environment »

Today's radiation protection framework is based upon « reference organisms »

« Reference organism » approach: biocentric



Anthropocentric concept → Biocentric concept

What is the reference organisms' approach ?

- A drastic simplification of the very large number of biota species, in order to settle an operational assessment methodology
- Concept inspired from « reference man » used in human radiation protection. ICRP selected 12 RAPs to be used as reference for comparison purposes
- Concept also aligned with conventional eco-toxicology methods where dose-responses are documented **for individual organisms** (man/surrogate, eco-test species)

« Reference organisms » approach entirely built upon effect responses of individual organisms

Restricts the scope of risk assessments to individual organisms

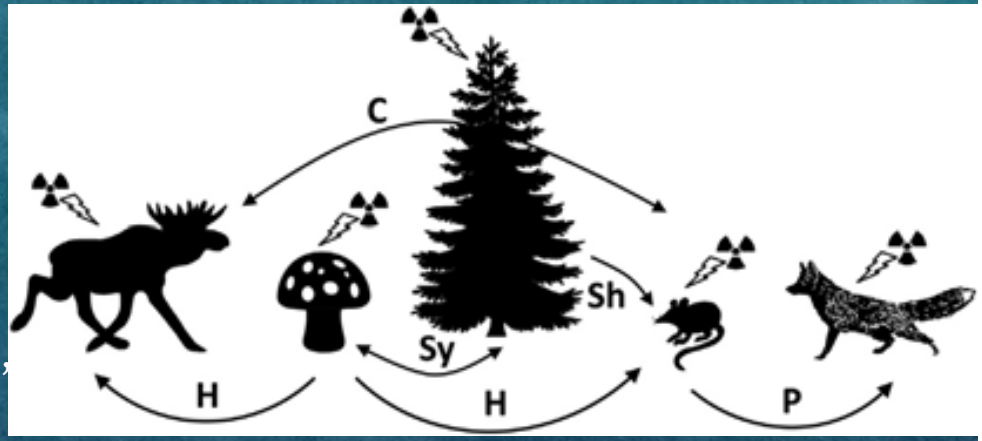
Individual organism/species-based frameworks do not address ecosystems

- Interactions between species and indirect effects not considered
- Non-linear responses, emergent properties, resilience, etc…, not addressed
- Effects at ecosystem level cannot be predicted/extrapolated from effects at individual organism/species level
- **Adequate to address biological effects, but may over- or underestimate ecological effects / risk**
- **May explain why in situ population/ecosystem level studies exhibit different/conflicting effects results …**

Why an “ecosystem approach” is needed ?

- Because objectives of protection are most usually set at population/ecosystem levels
- Because all organisms can only survive in the context of an ecosystem featuring obligatory interactions

  - Interactions between species, populations, biotic/abiotic
  - Emergent properties
  - Resilience, …

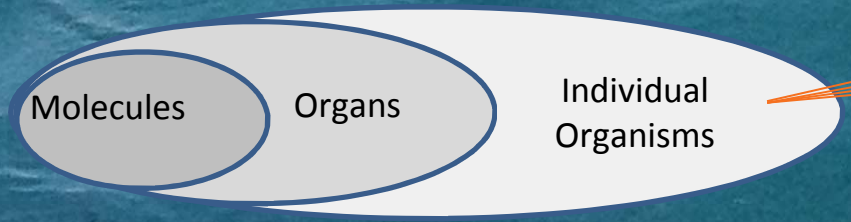


Bradshaw et al (2014) Fig 2.
C = competition, P = predation,
H = herbivory , Sy = symbiosis ,
Sh = shelter

Ecosystem approach is needed to meet the objectives of protection

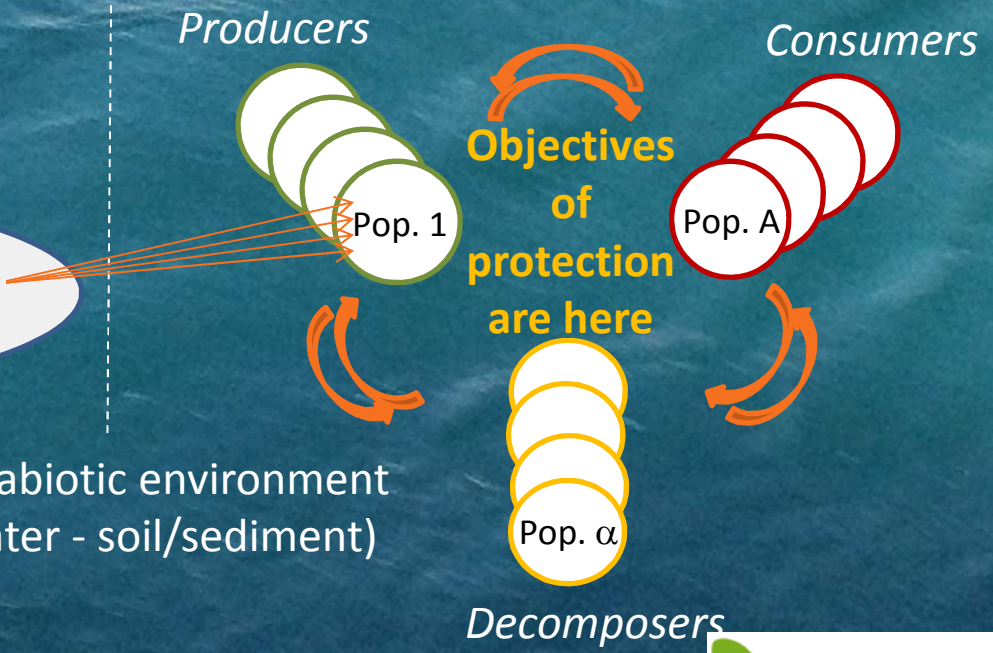
Biological impact of radiation (ICRP)

Imbricated system
(homeostatic stability)



Ecological impact of radiation (IUR-CERAD)

Network of species interactions
(submitted to abiotic variability)

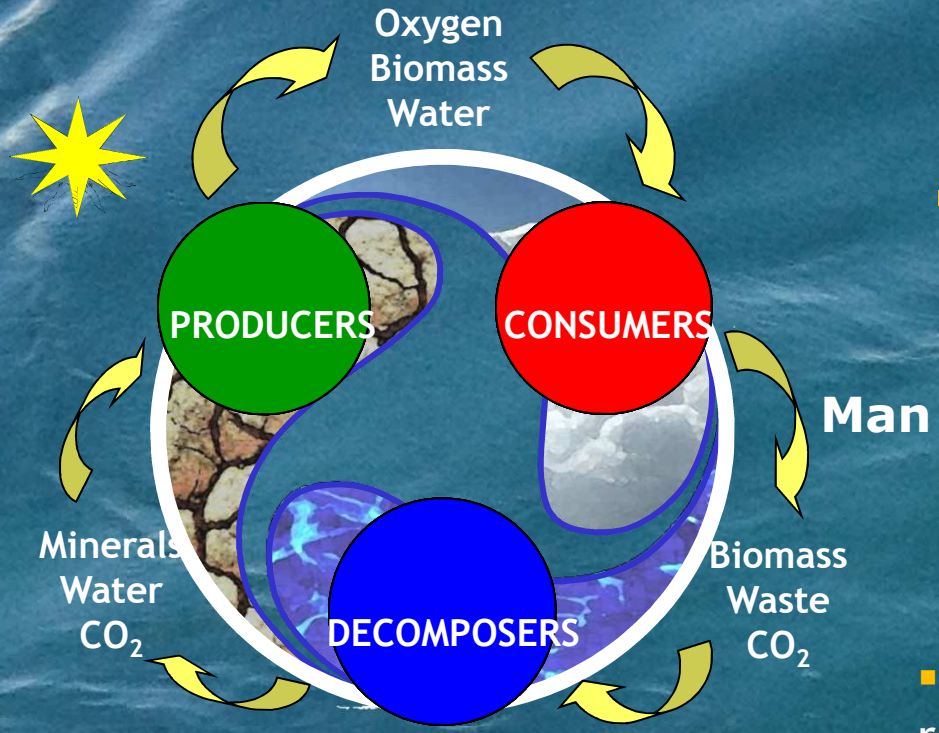


External abiotic environment
(air – water - soil/sediment)

Mismatch

Protection target	Individuals of endangered species	Populations / communities Structure and functions of ecosystems
Methods to achieve protection goals	**Reference organism approach** **Individual organism level endpoints:** • Early mobidity • Mortality • Reproductive success • Chromosome damage	**Ecosystem approach** **Population level endpoints:** • Population growth rate • Population density • Population size (numbers, biomass) • Population age/size structure • Net reproduction rate • Probability of extinction **Community-level endpoints:** **Structural** • Biodiversity • Taxonomic composition • Trait distribution • Food web structure **Functional** • Primary production • Biomass/energy flow • mineralization

« Ecosystem approach » enlarges the framework to an ecocentric vision



Environment including man

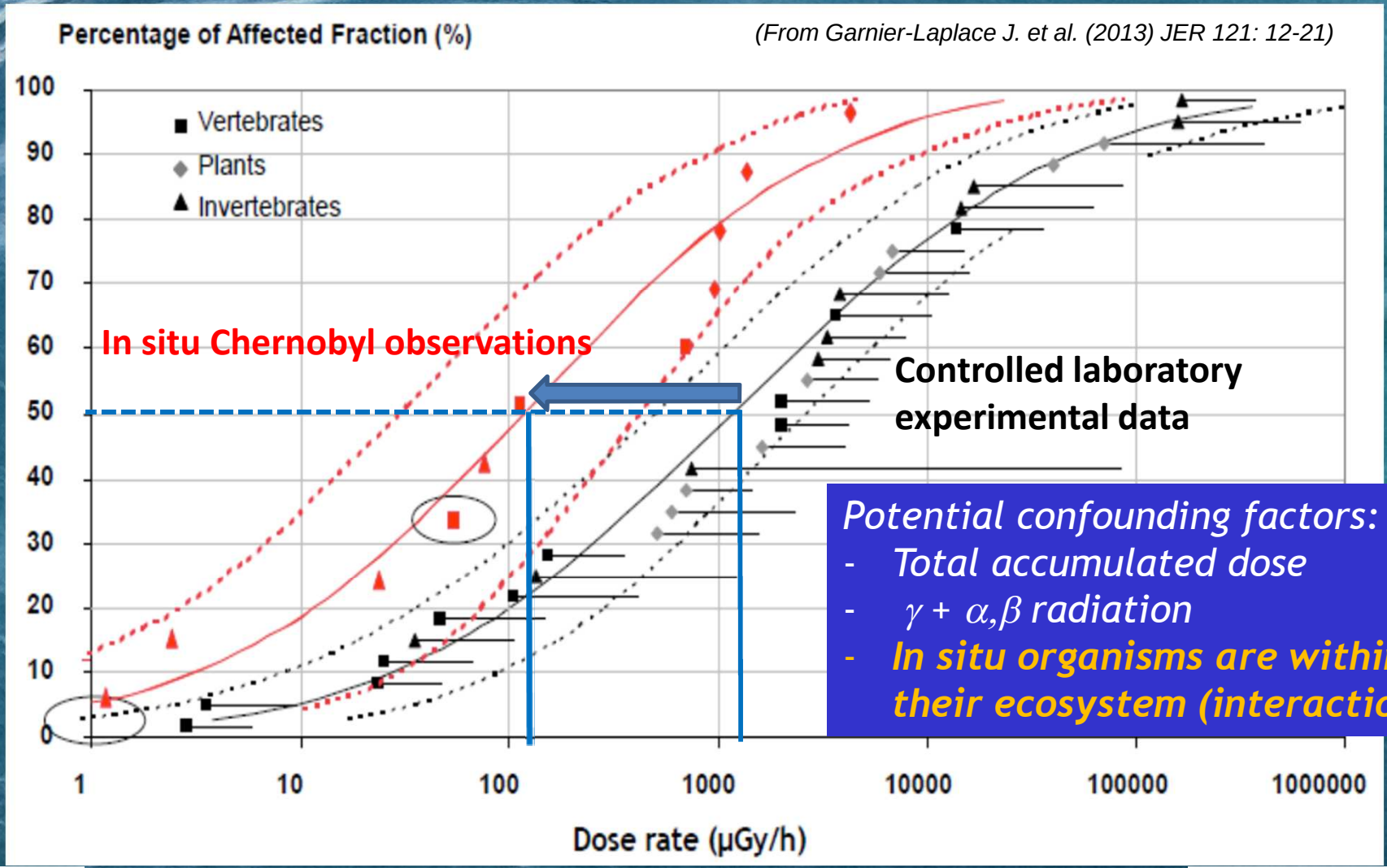
- **Ecosystem** = Biotope + biocenose

Air
Water
Soil
Sedim.

Animals
(man)
Plants
Microbes

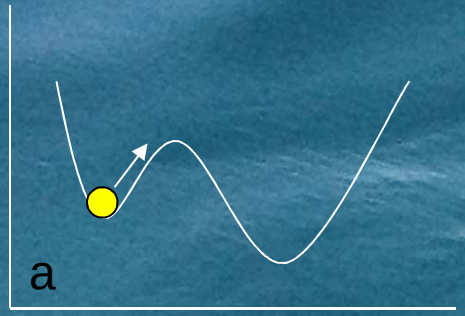
- **Services** (waste recycling, provision of ressources, …)
- **Life support** (water recycling, air bioregeneration, biomass production, …)

Interpretation of differences between laboratory experiments and in situ studies



Ecosystem resilience

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



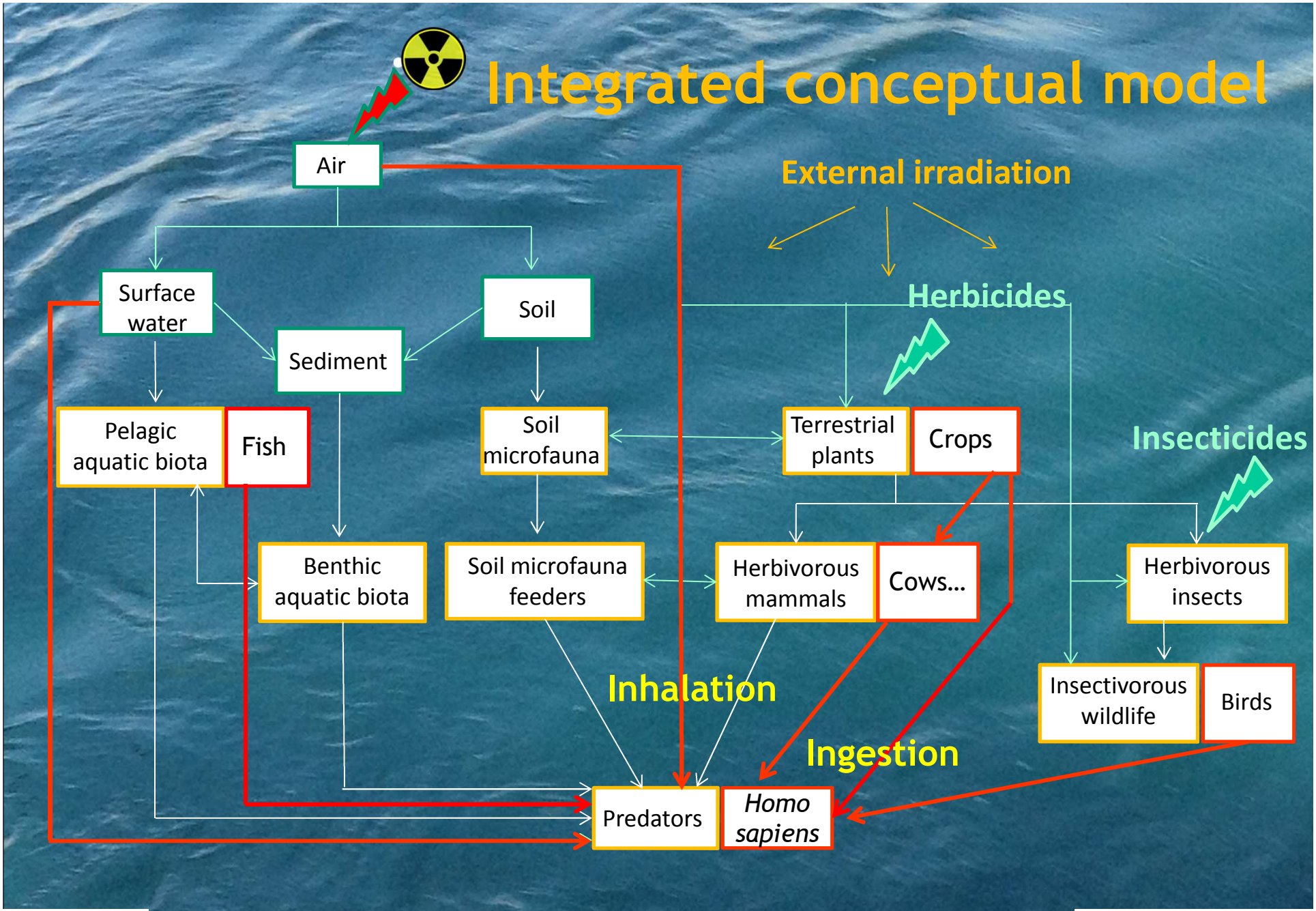
Highly resilient ecosystem

Poorly resilient ecosyst.

Explanation why various in situ studies have yielded contrasted effect results ?

Different critical thresholds of perturbation without effect ?

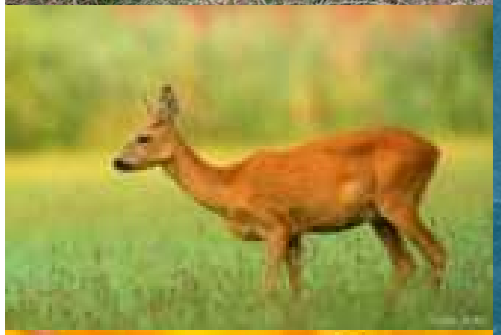
Are universal standards possible at all ?


Integrated conceptual model
Air
External irradiation
Surface water
Soil
Herbicides
Sediment
Pelagic aquatic biota
Fish
Soil microfauna
Terrestrial plants
Crops
Insecticides
Benthic aquatic biota
Soil microfauna feeders
Herbivorous mammals
Cows...
Herbivorous insects
Inhalation
Insectivorous wildlife
Birds
Ingestion
Predators
Homo sapiens

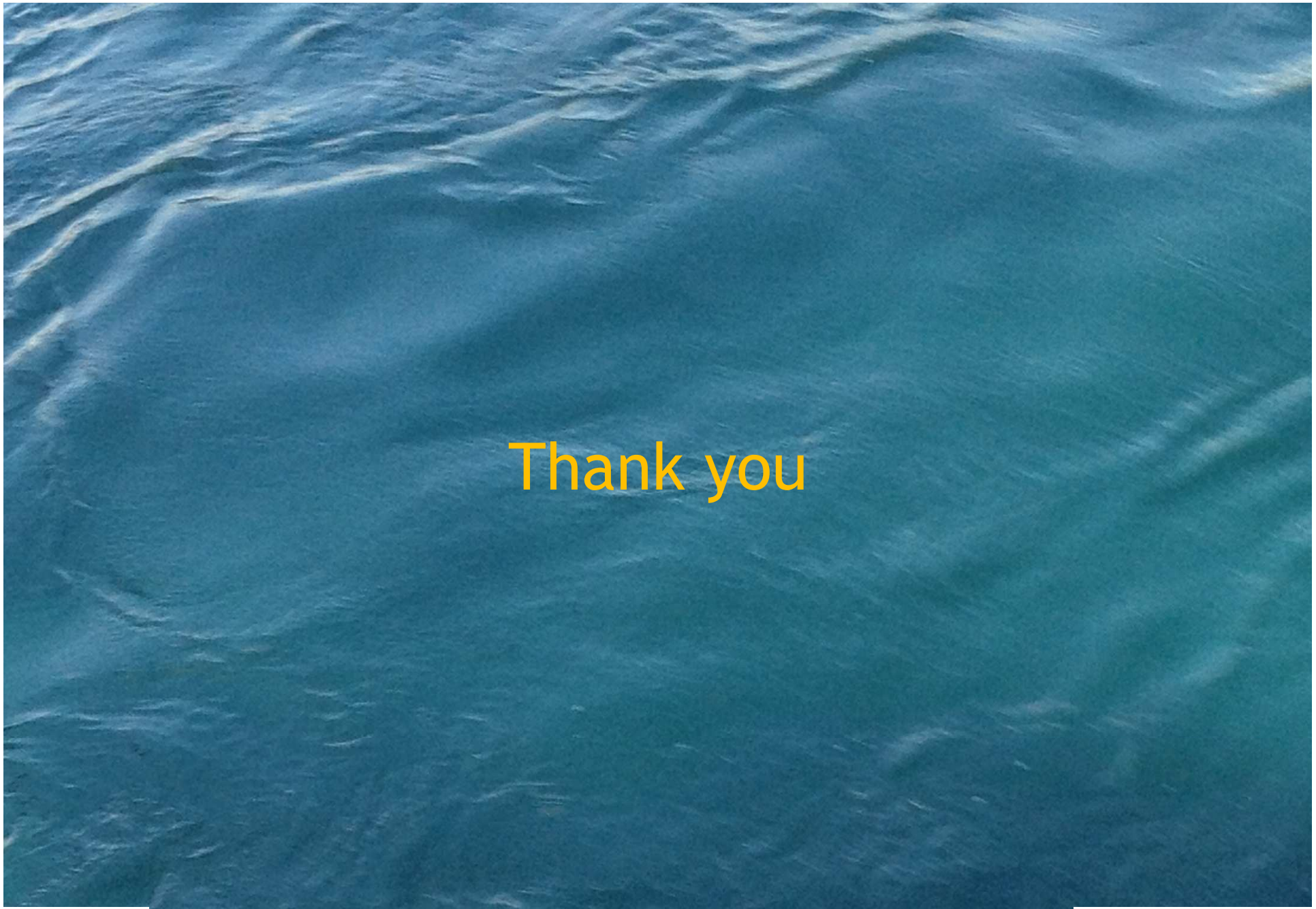
Comparative summary

Biocentric view	Ecocentric view
Biological effects	Ecological effects
based upon individual organism endpoints	based upon population and ecosystem level related endpoints
Reference organism approach	Ecosystem approach
Laboratory experiments in **controlled conditions**	In situ studies and experiments in **real conditions**

CONCLUSION
Ecosystem approach value



- Complements the « reference organisms » approach and compensates for its shortcomings
- Adresses both radiation and other hazards on the same grounds
- Yields a more convincing demonstration of protection because more directly aligned with protection obectives
- Sets the appropriate conceptual grounds for exploring if integration of human beings and populations of other species and their ecosystems within the radiation protection system is sensible and feasible


Thank you