Towards an ecosystem based approach in radioecology for environment protection

F. Bréchignac, C. Bradshaw

IUR Workshop
Ecological risk assessment of radiation - Putting the ecosystem approach into practice

Stockholm University, Sweden, 18-20 December 2013
Today’s radiation protection framework

- Legislation, existing or upcoming, requires environment protection measures for all stressors, with no exception for radioactivity
- Need to be able to demonstrate that the environment is indeed adequately protected
- Need to reconsider 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

Sources

CROP PLANTS

ANIMALS

Meat, milk

Targets

ENVIRONMENT

Air

Water

Soil

Sediment

WILDLIFE

PLANTS

ANIMALS

MAN

Workshop of the 2d IUR « Ecosystem approach » Task group, Stockholm University, Sweden, 18-20 December 2013
What are « reference organisms »

- Given the very large number of biota species, need to simplify by selecting a reduced number to settle the assessment methodology.

- Concept inspired from « reference man » used in human radiation protection. ICRP selected 12 RAPs to be documented and used as reference for comparison purposes.

- Concept also evolves from traditional methods of toxicology and ecotoxicology where dose-responses are documented for individual organisms (man/surrogate, eco-test species).

« Reference organisms » restrict the scope of risk assessments to individuals (leads to extrapolations).
Conceptual method entirely built upon individual organisms responses

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

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

Literature compilation

For effect endpoints in individuals

RN distribution (actual/modelled)

EXPOSURE

CR, TF
Dosimetry

Dose or dose rate (Gy.d⁻¹)

Effect intensity

Dose/dose rate

SCALE OF RISK

Workshop of the 2d IUR « Ecosystem approach » Task group, Stockholm University, Sweden, 18-20 December 2013
Scale of risk, based on dose-responses from individuals (for 4 endpoints)

Benchmarks from other studies

- Invertebrate benchmark
- Plant benchmark
- Generic benchmark
- Vertebrate benchmark
- Background level

- Seaweed
- Bee
- Crab
- Earthworm
- Deer
- Rat
- Duck
- Pine tree
- Frog
- Trout
- Flatfish
- Grass

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

Endpoints related to Individual organisms
- Early mobility
- Mortality
- Reproductive success
- Chromosome damage

Need for Endpoints related to POPULATIONS and ECOSYSTEMS

Endangered species
Protection of biodiversity
Pollution control
Nature conservation

Sectorial objectives (past trend)

Biological impact

Ecosystem approach

Ecological impact

Populations/communities
Structure and functions of ecosystems

Integrated objectives (today’s trend)
Biocentric approach partially meets EP objectives

Organismal approach

Toxicology

DNA-RNA
Membrane receptors
Key enzymes

Site of action

Molecules
(Biotransformation parameters)

Cells
(Biochemical parameters)

Organisms
(Physiol. parameters: mortality, morbidity, reproductive success, mutation)

Ecotoxicology

Community
(Structure, diversity, energy transfer efficiency, stability, ...)

Ecosystem effects

Population
(Density, productivity, mating success, competitive alterations)

Inheritable genome, homeostasy

Historical traits, non-linearity, chaotic behaviour around attractors

Eco-systemic approach

Ecology

Population
(Density, productivity, mating success, competitive alterations)

Historical traits, non-linearity, chaotic behaviour around attractors
Biocentric approach does not meet general environment protection objectives

« Reference organism approach » is totally grounded upon individual responses to radiation, with no consideration of higher levels of organisation where ecological impacts occur

- Methodology is mismatched with regard to the objectives of protection it is meant to support (protection of populations and beyond... not only individual organisms)

- 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
First IUR Task Group gathering wide radiation proficiencies

Report now published with recommendations

Order at:  www.iur-uir.org

Now: 2d IUR Task group to follow up upon recommendations
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)
  - OSPAR (Bergen statement, sept 2010)
  - UNEP (in relation to IAEA revision of IBSS, June 2010)
What is the « ecosystem approach »? Enlarging the framework to an ecocentric vision

Environment including man

- Ecosystem = Biotope + biocenose
  - Air
  - Water
  - Soil
  - Sedim.
  - Animals
  - Plants
  - Microbes

- Services (waste recycling, provision of resources, ...)
- Life support (water recycling, air bioregeneration, biomass production, ...)

Workshop of the 2d IUR « Ecosystem approach » Task group, Stockholm University, Sweden, 18-20 December 2013
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 structure)
  - Biodiversity indexes (genetic structure)

- Endpoints related to ecosystem functioning:
  - Rate of primary productivity (photosynthesis)
  - Rate of energy cycling
  - Rate of N 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,...