The concept of protection of the environment and the Committee 5 current approach

Joint IES-ICRP Symposium

Aomori, Japan, October 4, 2016

David Copplestone on behalf of all of C5

Secretary, ICRP Committee 5

ICRP 91 (2003)

Review of ethics and principles, recommending that the System for Environmental Protection should

- *focus on biota;*
- *consider **adequate protection** on the basis of understanding of effects;*
- *identify reference animals and plants (RAPs); and*
- *let the RAPs guide the derivation of*
  - *exposure scenarios (CFs and DCFs)*
  - *effects data*
  - *dose rates benchmarks*

ICRP Publication 103

2. THE AIMS AND SCOPE OF THE RECOMMENDATIONS

2.1. The aims of the Recommendations

(26) The primary aim of the Commission's Recommendations is to contribute to an appropriate level of protection for people and the environment against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure.

(27) This aim cannot be achieved solely on the basis of scientific knowledge on

ICRP Publication 103 – protection goals

of how decisions have been reached.

(28) Radiological protection deals with two types of harmful effect. High doses will cause deterministic effects (harmful tissue reactions, see Chapter 3), often of an acute nature, which only appear if the dose exceeds a threshold value. Both high and low doses may cause stochastic effects (cancer or heritable effects), which may be observed as a statistically detectable increase in the incidences of these effects occurring long after exposure.

(29) The Commission's system of radiological protection aims primarily to protect human health. Its health objectives are relatively straightforward: to manage and control exposures to ionising radiation so that deterministic effects are prevented, and the risks of stochastic effects are reduced to the extent reasonably achievable.

(30) In contrast, there is no simple or single universal definition of 'environmental protection' and the concept differs from country to country and from one circum-

ICRP103

(30) ….aim is…preventing and reducing the frequency of deleterious radiation effects to a level where they would have negligible impact on the maintenance of **biological diversity**, the **conservation of species**, or the health and status of **natural habitats**, **communities** and **ecosystems**.

(366) .....Reference Animals and Plants.......

ICRP103

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ICRP103

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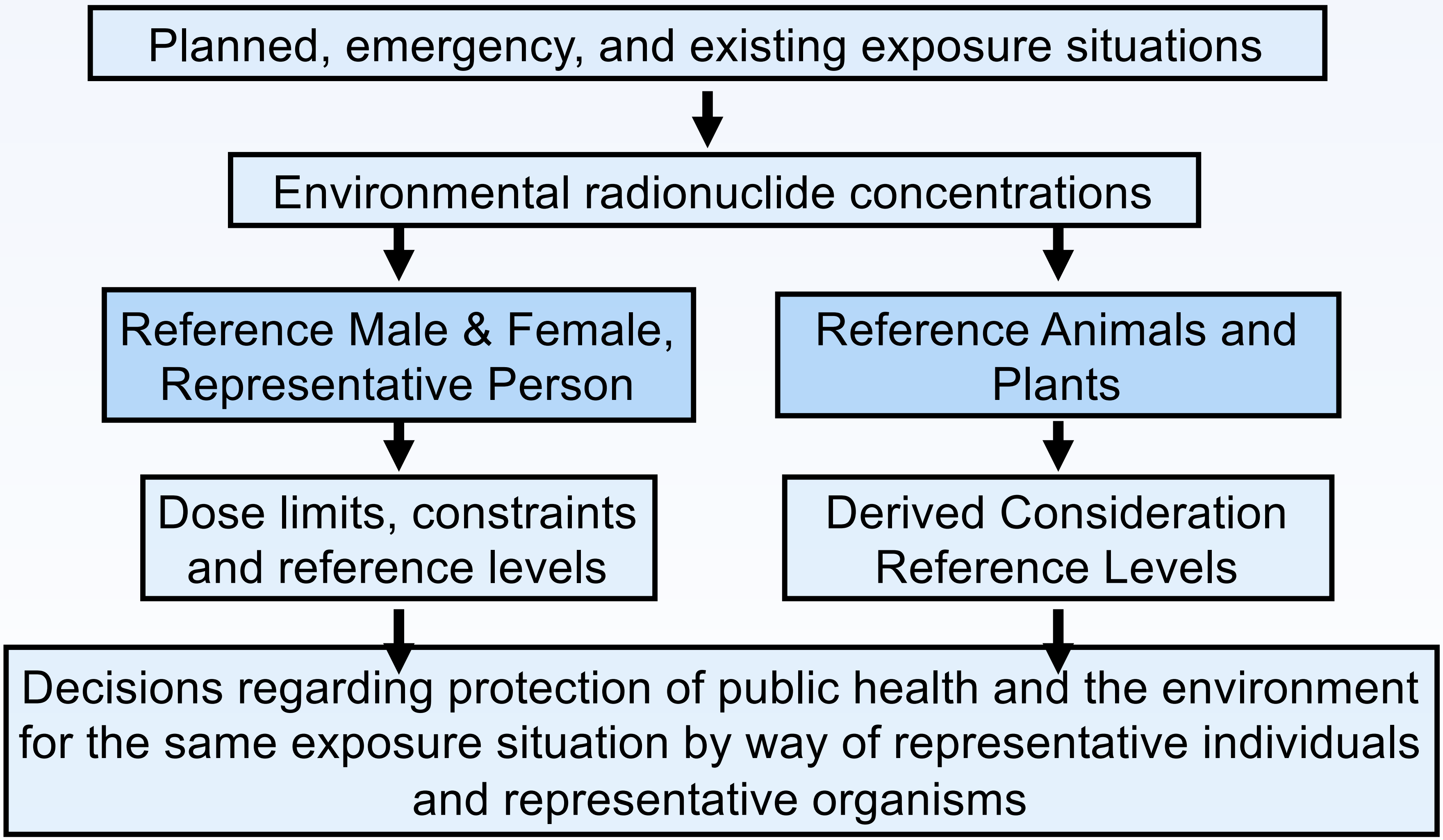
(366) .....Reference Animals and Plants.......

There is ONE system of radiological protection

So .....

- **Why do I say this?**
- **Does it work?**
- **What the similarities and differences in application for humans and the environment?**
  - Absence of humans from some environments
  - Protection goals etc.
- **Assessments…**
- **What remains to be done/challenges?**

Evolution of Protection System



[*Publication 108*]

ICRP 108

WILDLIFE GROUP	RAP
Large terrestrial mammals	Deer
Small terrestrial mammals	Rat
Aquatic birds	Duck
Amphibians	Frog
Freshwater pelagic fish	Trout
Marine fish	Flatfish
Terrestrial insects	Bee
Marine crustaceans	Crab
Terrestrial annelids	Earthworm
Large terrestrial plants	Pine tree
Small terrestrial plants	Wild grass
Seaweeds	Brown seaweed

ICRP 108

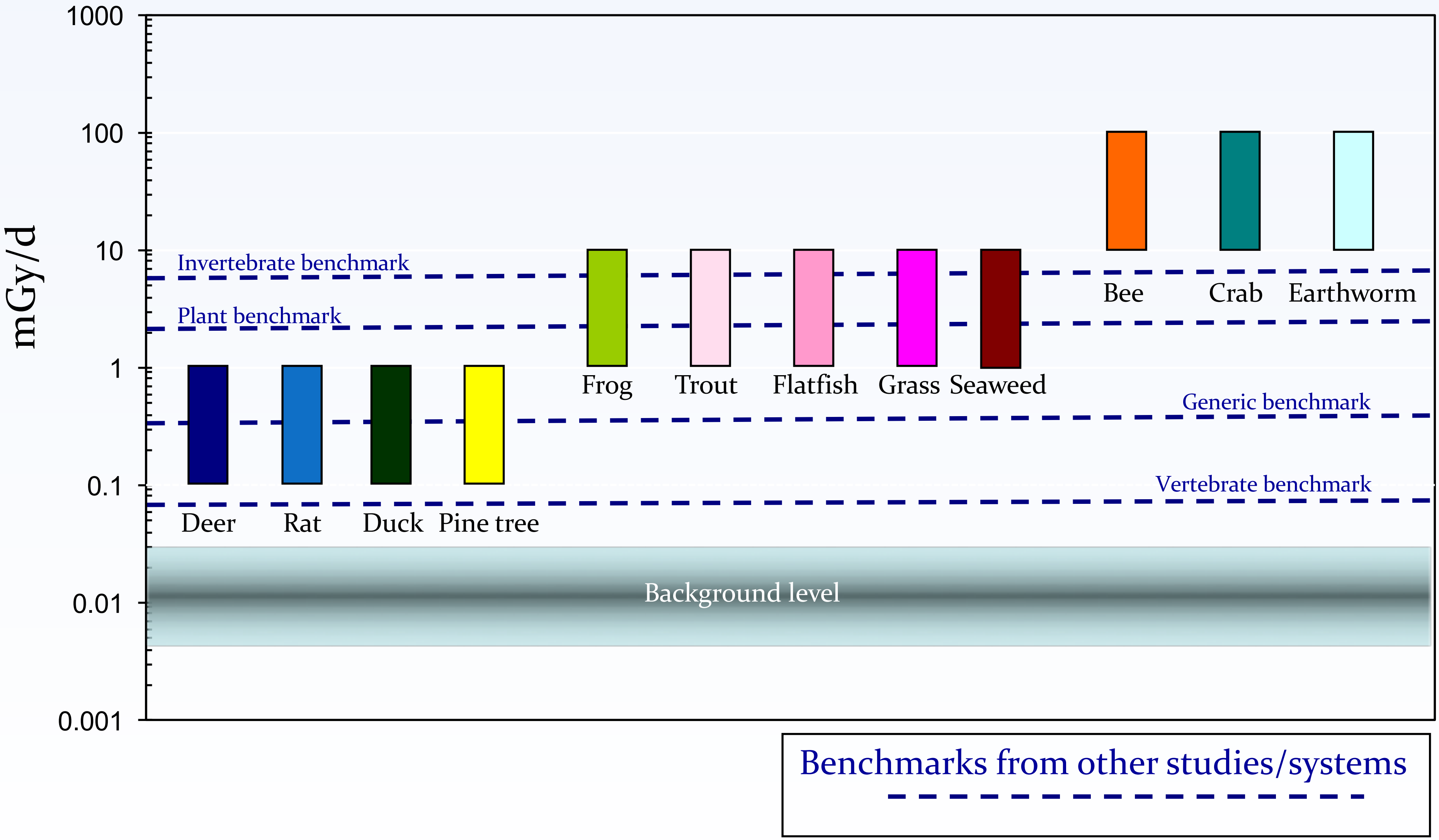
ICRP 108 reviews biological characteristics

- *Occurrence*
- *Taxonomy*
- *Life cycle and life span*
- *Reproductive strategy*
- *Physiology*
- *Ecology*
- *.....other factors.....*

RAP selection

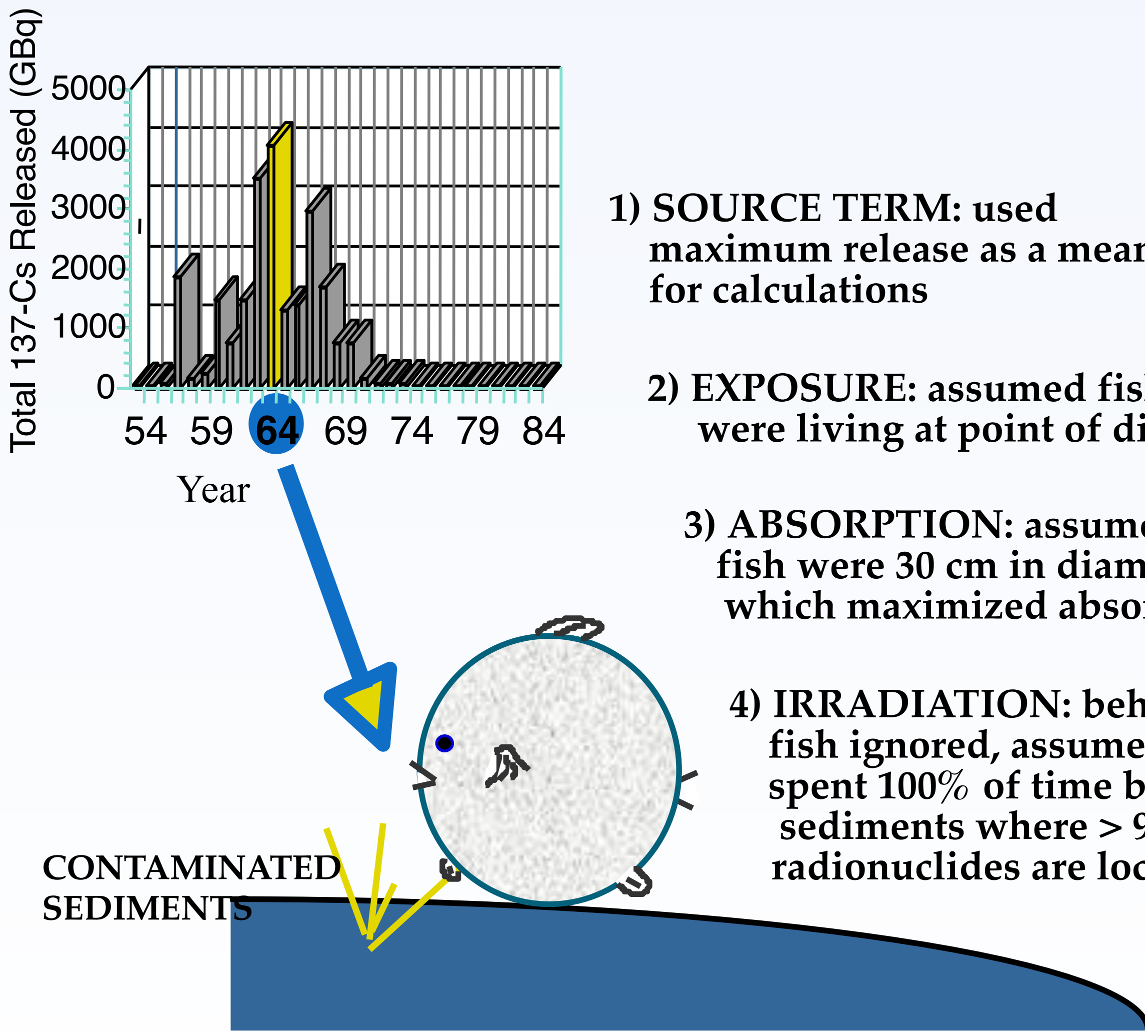
- Pragmatic
- Covering different ecosystems
- Example animals/plants
- Considering application as species of conservation interest
- Where possible geographic spread
- Allowing for transboundary (e.g. birds)
- Different lifestages
- Amount of available information
- Potential for future studies

ICRP 108 Derived Consideration Reference Levels, DCRLs



Assessments

Are they integrated or not?



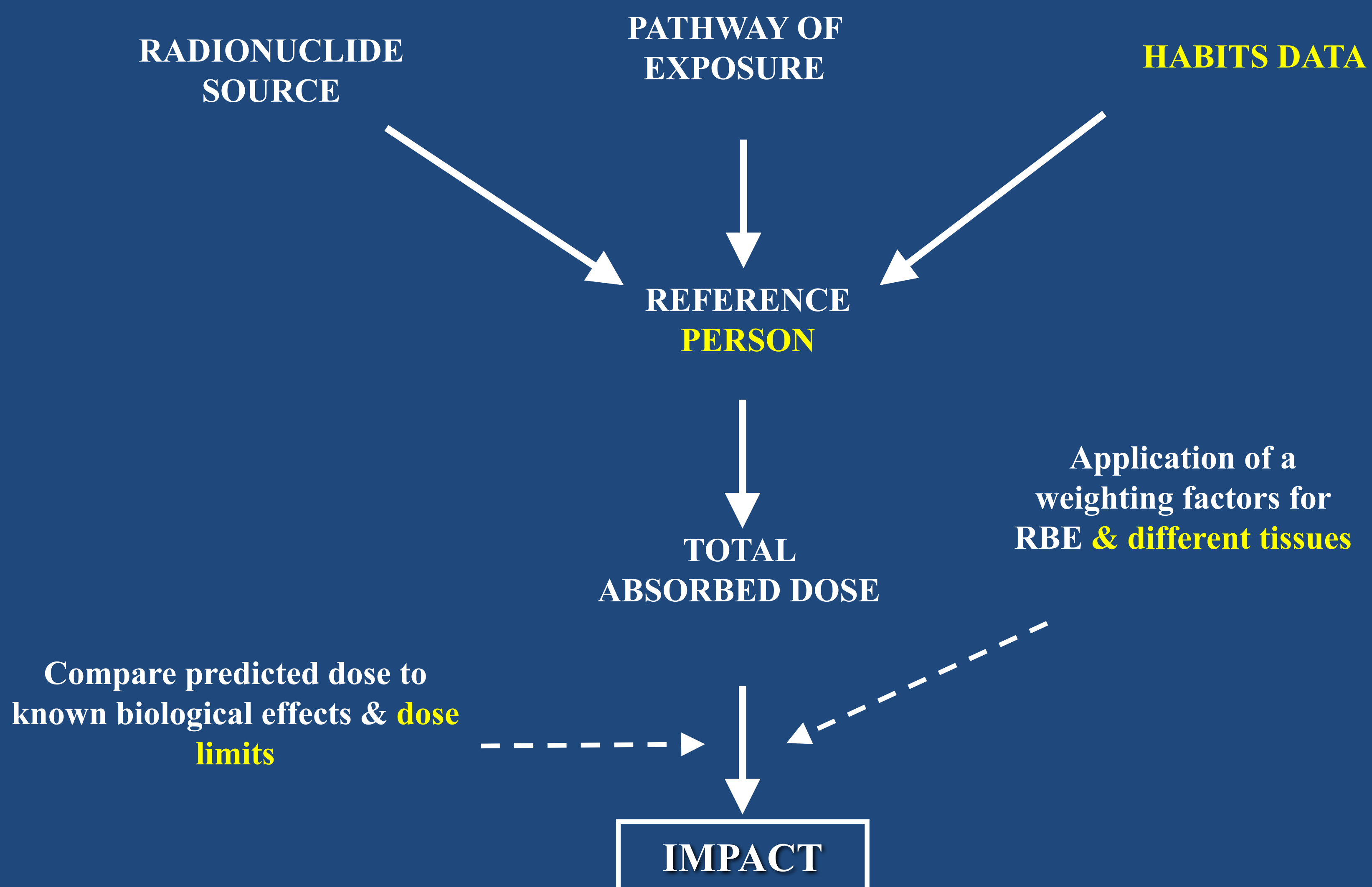
1) **SOURCE TERM: used maximum release as a mean for calculations**

2) **EXPOSURE: assumed fish were living at point of discharge**

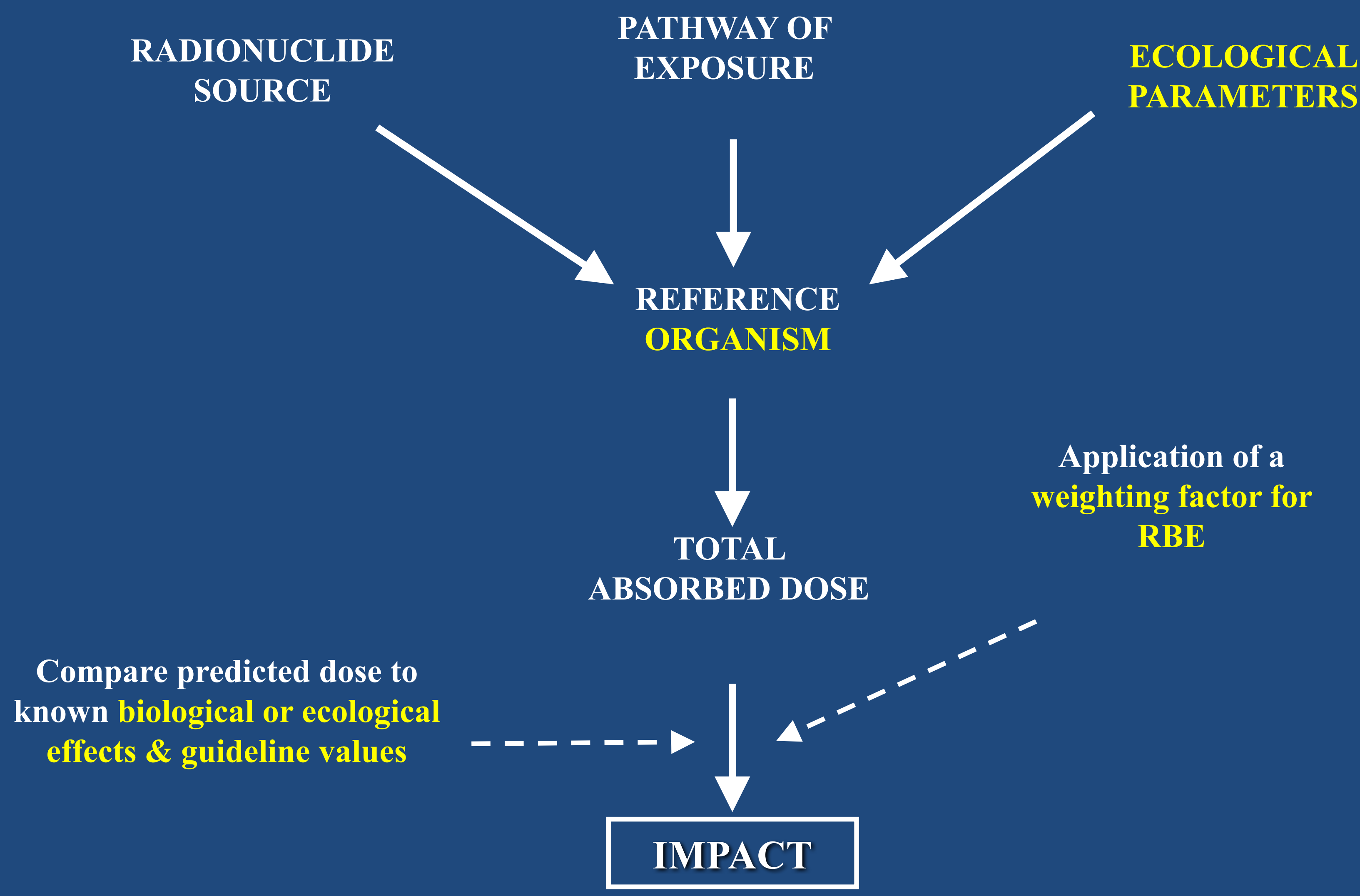
3) **ABSORPTION: assumed all fish were 30 cm in diameter which maximized absorbed dose**

4) **IRRADIATION: behavior of fish ignored, assumed they spent 100% of time bottom sediments where > 90% of radionuclides are located**

Human assessment (overview)



Non-human species assessment (overview)

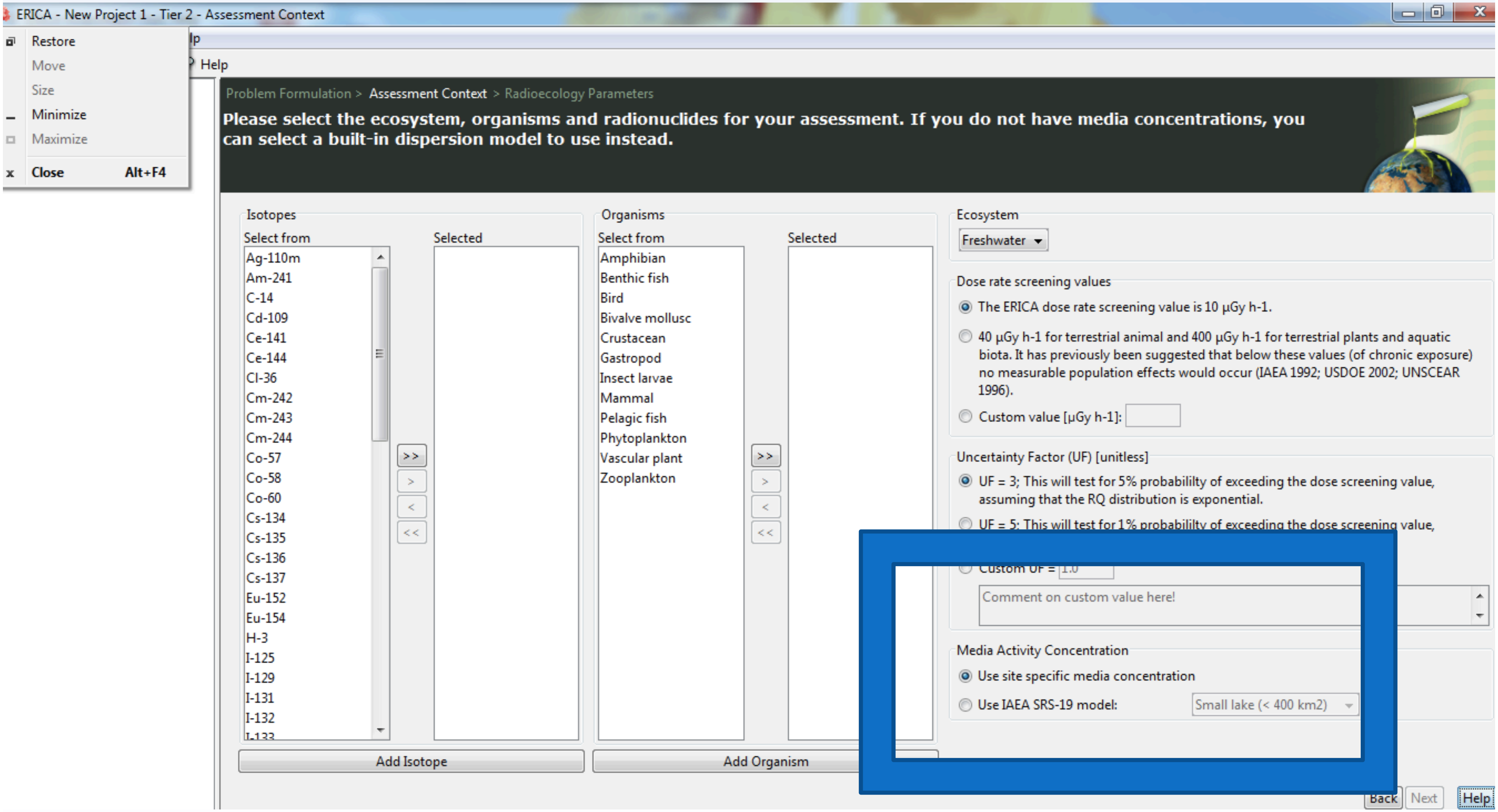



Source term

Source

- **Site specific models**
  - Used for human dose assessments
  - Take into account local features
  - Etc.

- **But seen wildlife dose assessments that, because a different tool used, and tick box approach…..**

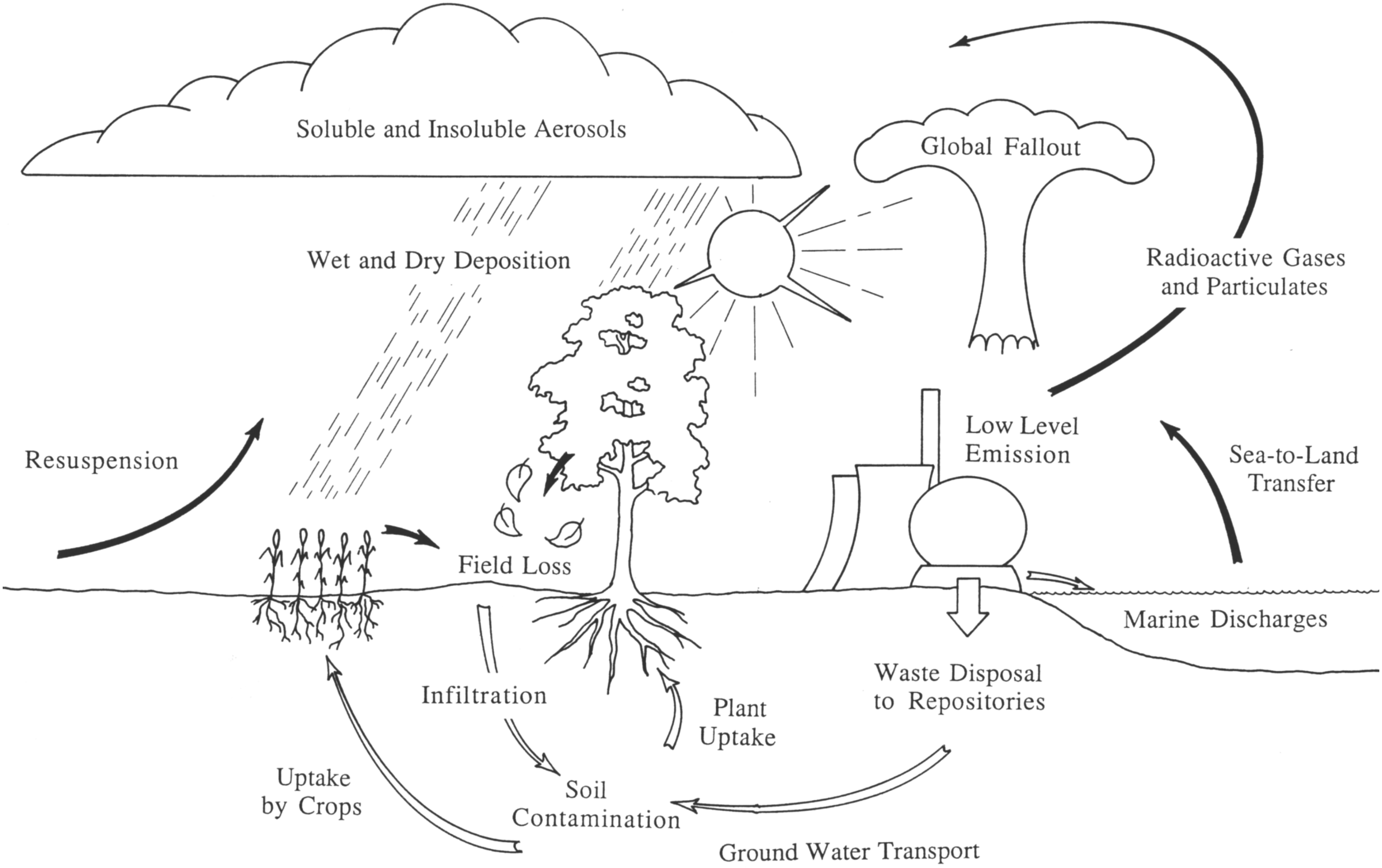

ERICA - New Project 1 - Tier 2 - Assessment Context
Restore
Move
Size
Minimize
Maximize
Close Alt+F4
Help
Problem Formulation > Assessment Context > Radioecology Parameters
Please select the ecosystem, organisms and radionuclides for your assessment. If you do not have media concentrations, you can select a built-in dispersion model to use instead.
Isotopes
Select from
Selected
Ag-110m
Am-241
C-14
Cd-109
Ce-141
Ce-144
Cl-36
Cm-242
Cm-243
Cm-244
Co-57
Co-58
Co-60
Cs-134
Cs-135
Cs-136
Cs-137
Eu-152
Eu-154
H-3
I-125
I-129
I-131
I-132
Add Isotope
Organisms
Select from
Selected
Amphibian
Benthic fish
Bird
Bivalve mollusc
Crustacean
Gastropod
Insect larvae
Mammal
Pelagic fish
Phytoplankton
Vascular plant
Zooplankton
Add Organism
Ecosystem
Freshwater
Dose rate screening values
The ERICA dose rate screening value is 10 µGy h-1.
40 µGy h-1 for terrestrial animal and 400 µGy h-1 for terrestrial plants and aquatic biota. It has previously been suggested that below these values (of chronic exposure) no measurable population effects would occur (IAEA 1992; USDOE 2002; UNSCEAR 1996).
Custom value [µGy h-1]:
Uncertainty Factor (UF) [unitless]
UF = 3; This will test for 5% probability of exceeding the dose screening value, assuming that the RQ distribution is exponential.
Comment on custom value here!
Media Activity Concentration
Use site specific media concentration
Use IAEA SRS-19 model:
Small lake (< 400 km2)
Back
Next
Help

Result

- **Different source terms being used for wildlife and humans…..**

    - Leads to discrepancies between human and wildlife dose assessments
    - Leads to communication issues
    - Etc.

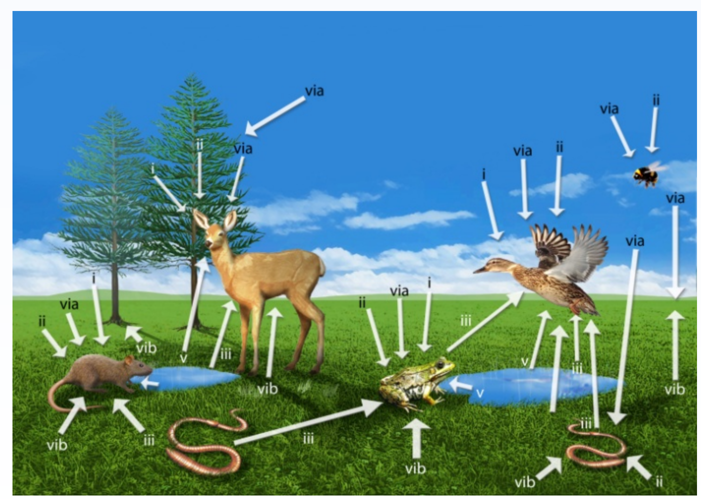
Pathways of exposure

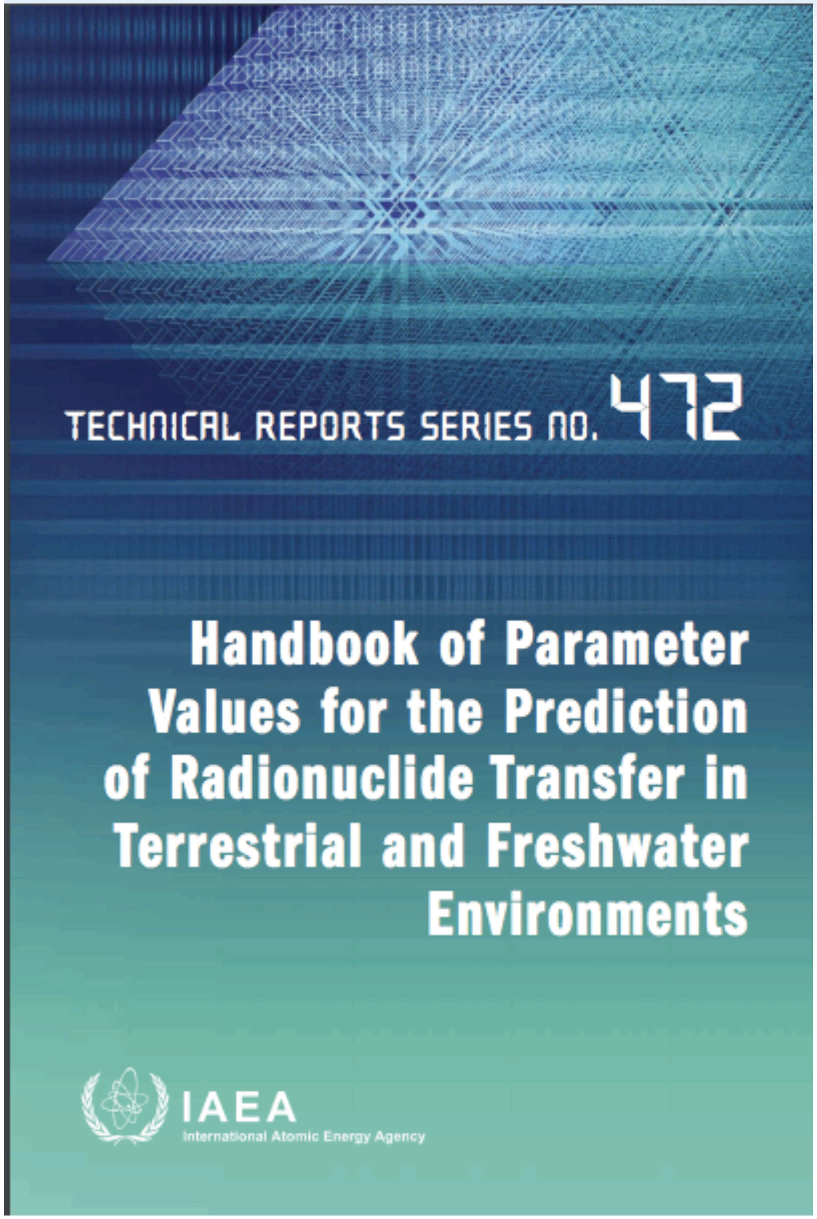


ICRP 114

Concentration Ratios for 39 elements and 12 RAPs

- *with associated statistics;*
- *based on existing field and laboratory data;*
- *using new methodology to derive data ('surrogate data') where such are missing;*
- *taking in to account life cycle stages and habitats, when possible; and*
- *discussing the robustness of the data*




TECHNICAL REPORTS SERIES NO. 472
Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments
IAEA
International Atomic Energy Agency

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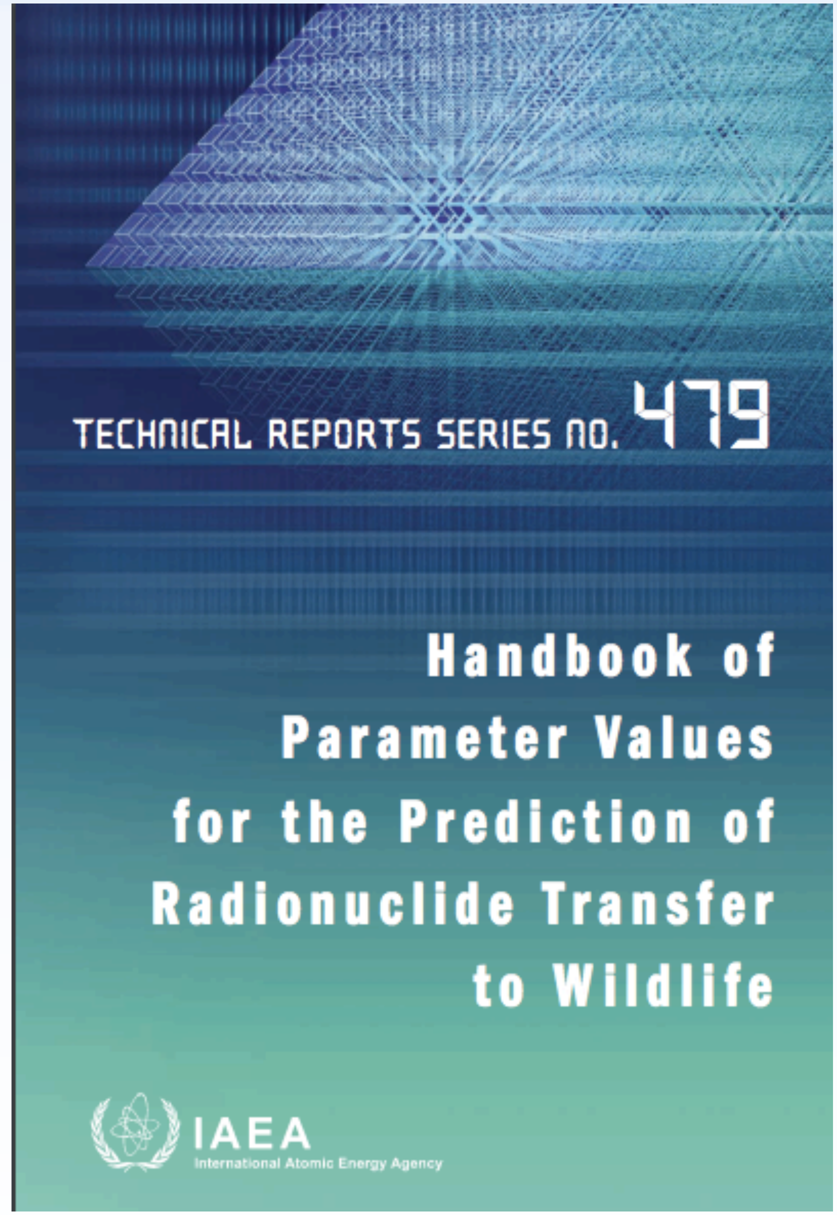
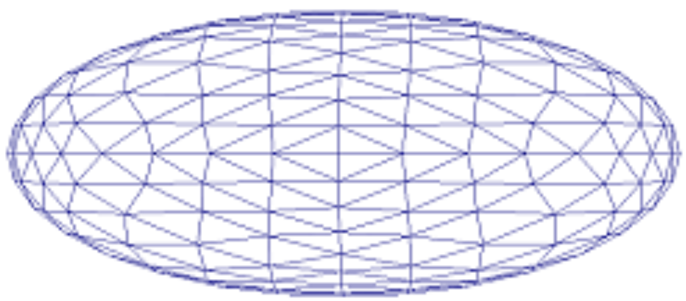

TECHNICAL REPORTS SERIES NO. 479
Handbook of Parameter Values for the Prediction of Radionuclide Transfer to Wildlife
IAEA
International Atomic Energy Agency

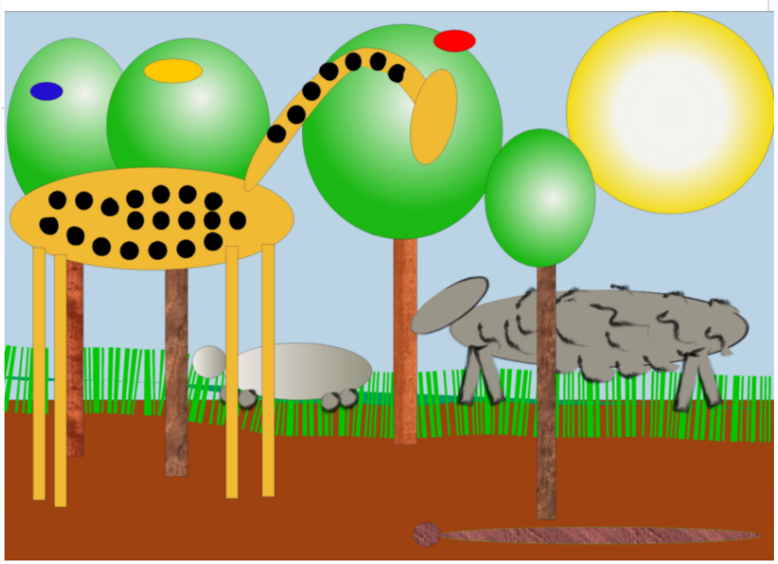
Commonly through transfer

- **Not integrated**
  - Underpinning databases are different
  - Noting that in many cases (as ICRP) it is generally about protection of biodiversity although IAEA consider the importance of environmental resources
- **Things to consider**
  - Livestock are not generally considered within environmental protection assessments (are they protected by the human assessments?)
- **Potential issues**
  - Non equilibrium situations

Dosimetry

DCCs for simple geometries





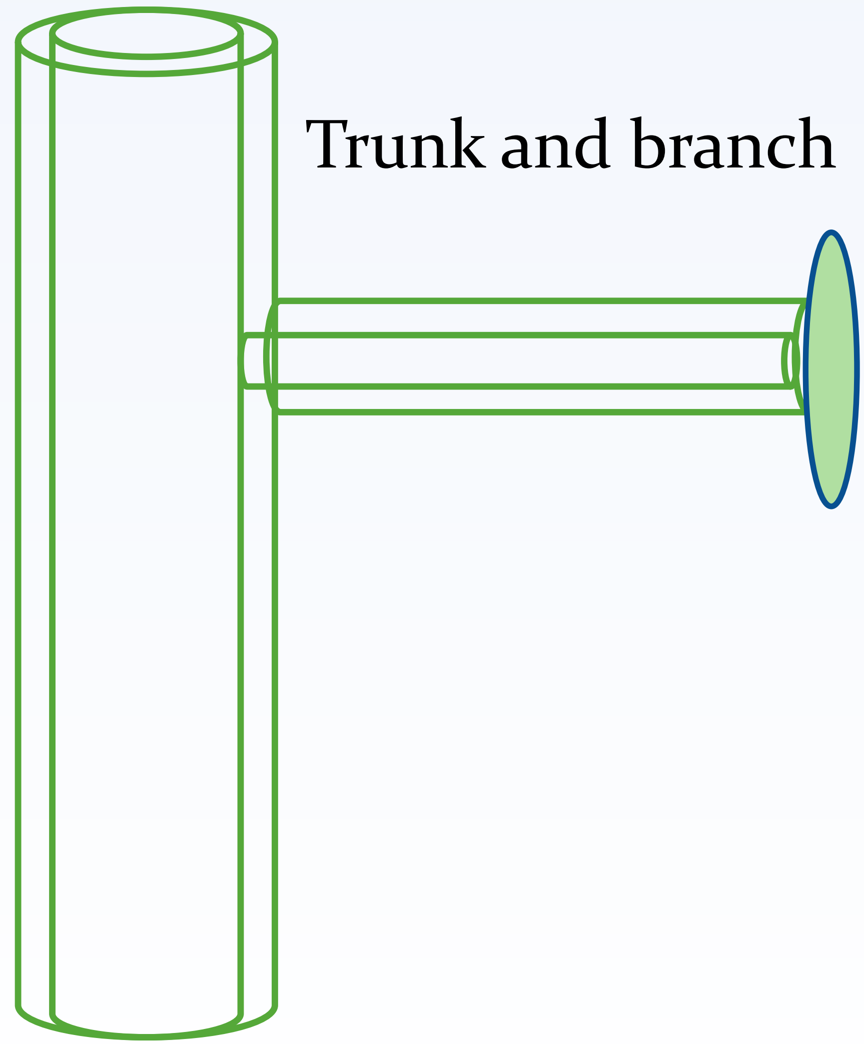


Table 4.3 Summary of exposure geometry assumptions.

Reference Animals and Plants	Aquatic environment	Terrestrial environment		
		On soil		In soil
		Planar source	Volume source	
Deer adult		X	X	
Rat adult		X	X	X
Duck egg		X	X	
Duck	X	X	X	
Frog egg	X			
Frog egg mass	X			
Frog tadpole	X			
Frog adult	X	X	X	
Trout egg	X			
Trout	X			
Flatfish egg	X			
Flatfish	X			
Crab egg mass	X			
Crab larvae	X			
Crab	X			
Bee		X	X	
Bee colony		X	X	
Earthworm egg				X
Earthworm				X
Pine tree		X	X	
Grass		X	X	
Brown seaweed	X			

Simple shapes but…

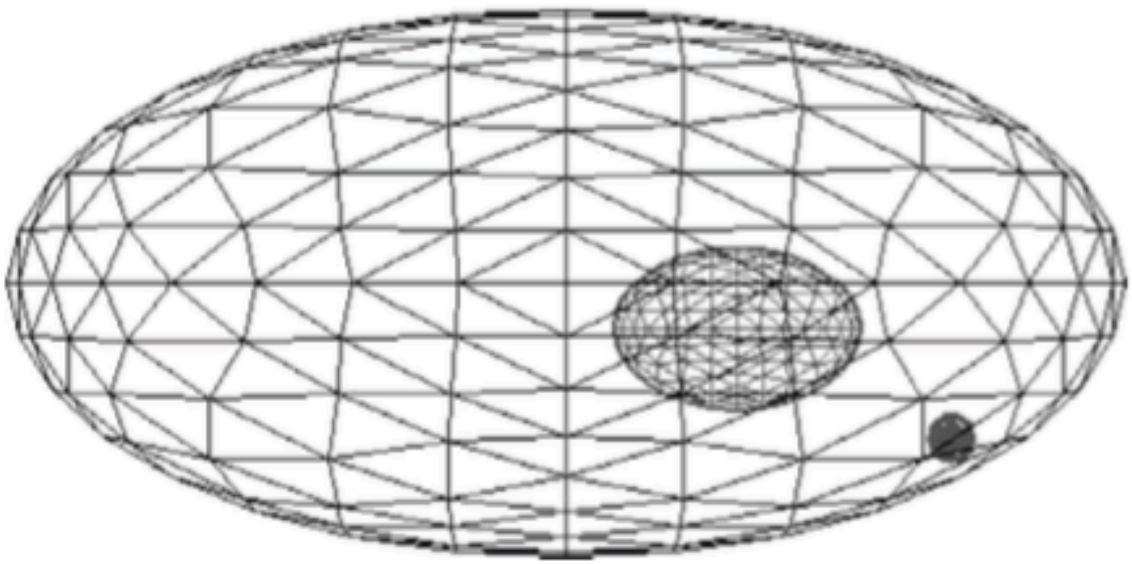
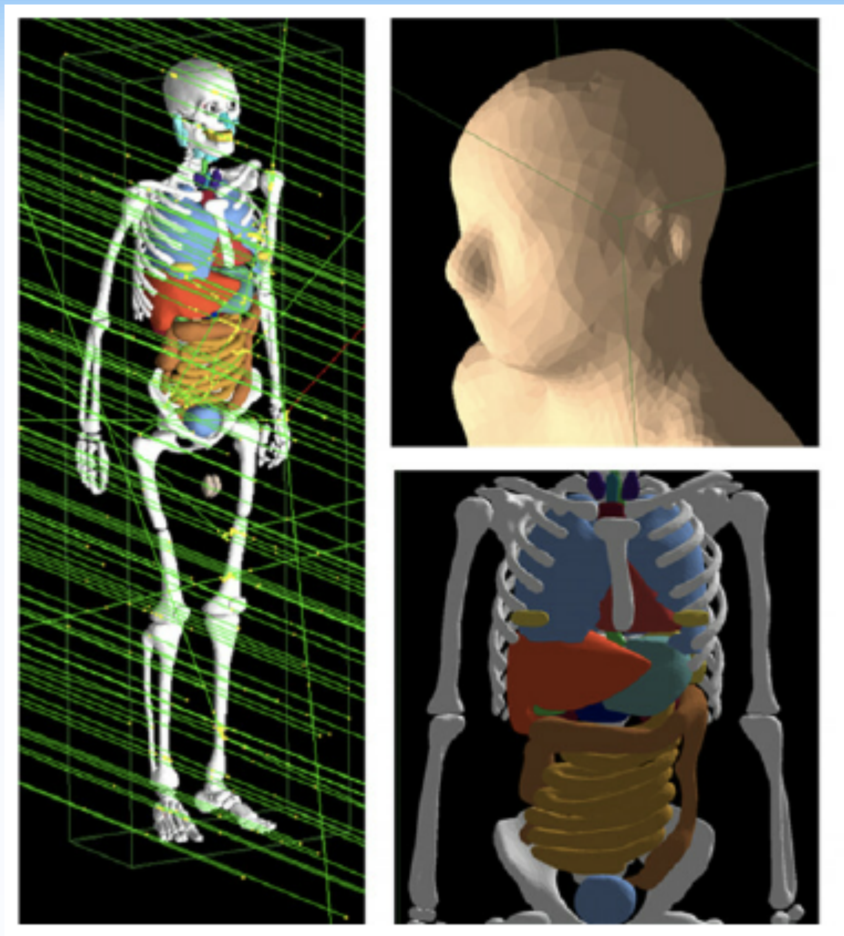
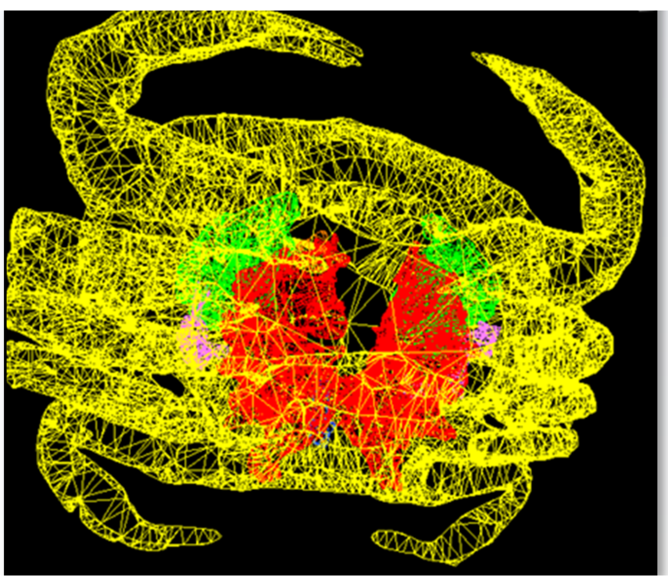
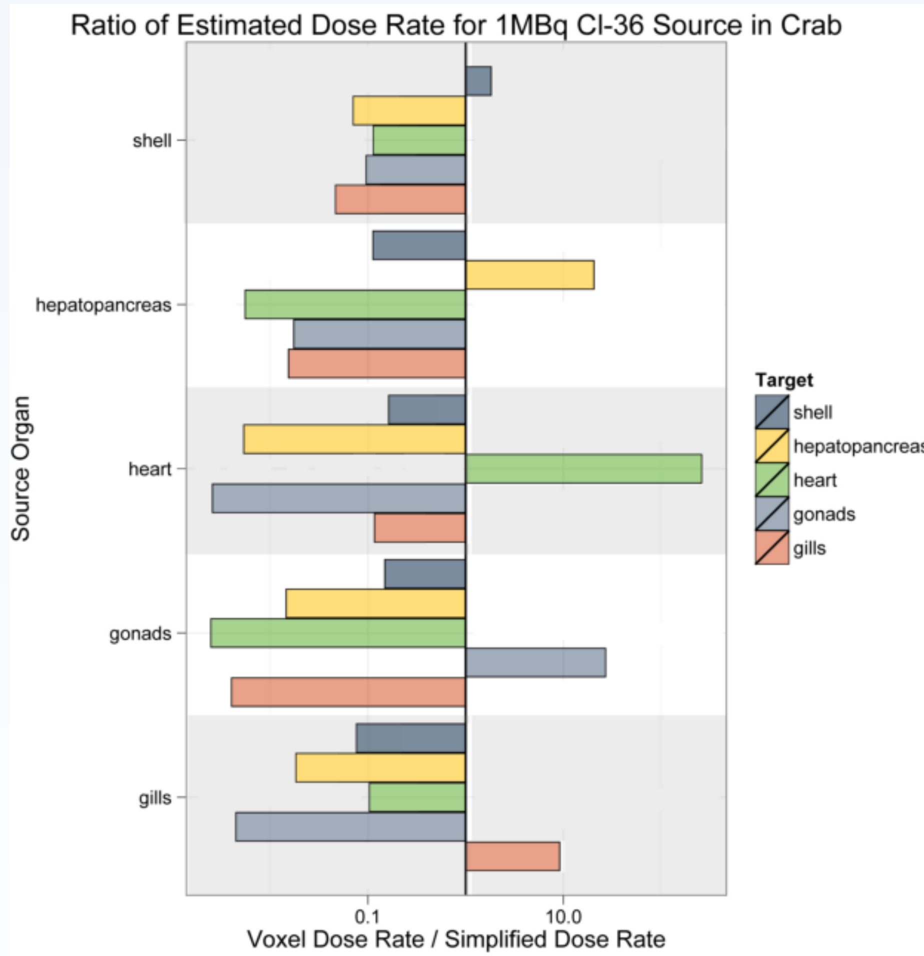


Fig. 4.4. Geometrical model of deer body with liver (large inner ellipsoid) and testes (small inner ellipsoid).

Voxel phantoms







Higley et al. *Ann ICRP 44* (2015) pp 313-330

Issues

- Level of complexity?
- Pragmatic and ease to use?
- Needed for whole body dosimetry as required for wildlife from regulatory perspective?
- Good for testing whether the simple ellipsoid is sufficient for our modelling for wildlife?
- And may help with interpreting field effects data

Effects/benchmarks for wildlife

Evaluation of Radiation Effects on Wildlife

- **Based on expert judgement**
  - All documented in Publication 108
- **UNSCEAR reports and FREDERICA as sources of information**

www.frederica-online.org

FREDERICA Radiation Effects Database

The FRED database was originally created as part of the EC fifth framework project FASSET (Framework for the Assessment of Environmental Impact, Contract No.: FIGE-CT-2000-00102) and its main use was to gather literature data to help summarise dose-effect relationships between radiation exposures and their effects on organisms.

The database has been extended, improved and made more user-friendly as part of the EC's sixth framework project ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management, Contract No.: FI6R-CT-2004-508847). The database is now called FREDERICA and is available for use on it's own or in conjunction with the ERICA assessment tool for undertaking risk assessments for the impact of ionising radiation on non-human species.

Please note that the site should be accessed using Internet Explorer only (changes to allow other browers to be used will be made in the future.

The ERICA project website can be accessed from here.

The ERICA deliverable (D1) for this project can be downloaded here as a pdf

Download a manual describing the use of FREDERICA here

If you are not registered, Register Now

If you have forgotten your login details please email us and we will send you a reminder (Password Reminder)

User Name

Password

Login

Evaluation of Radiation Effects on Wildlife

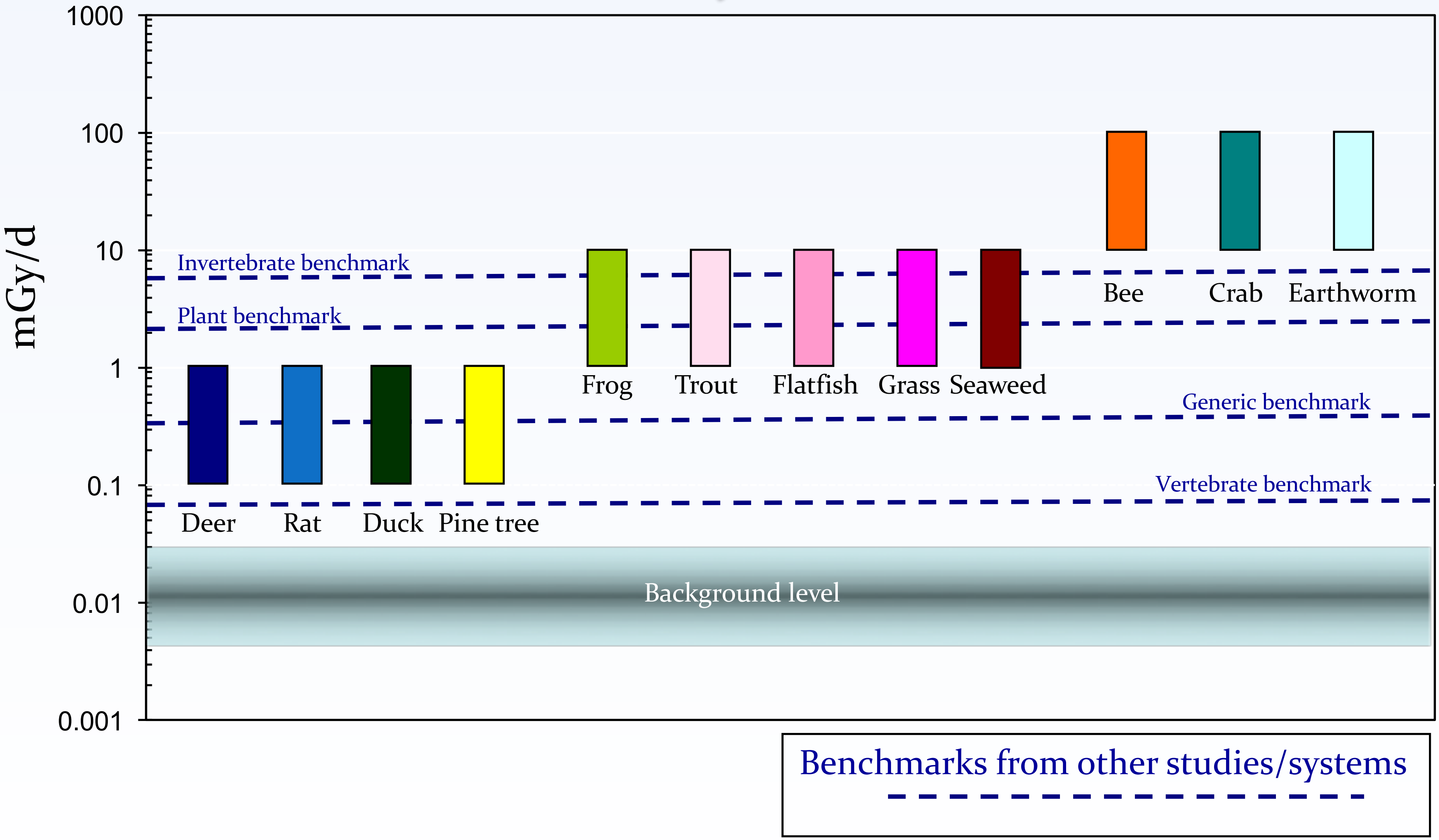
- Based on expert judgement
  - All documented in Publication 108

- UNSCEAR reports and FREDERICA as sources of information

- Again focused on RAPs at Family level where possible

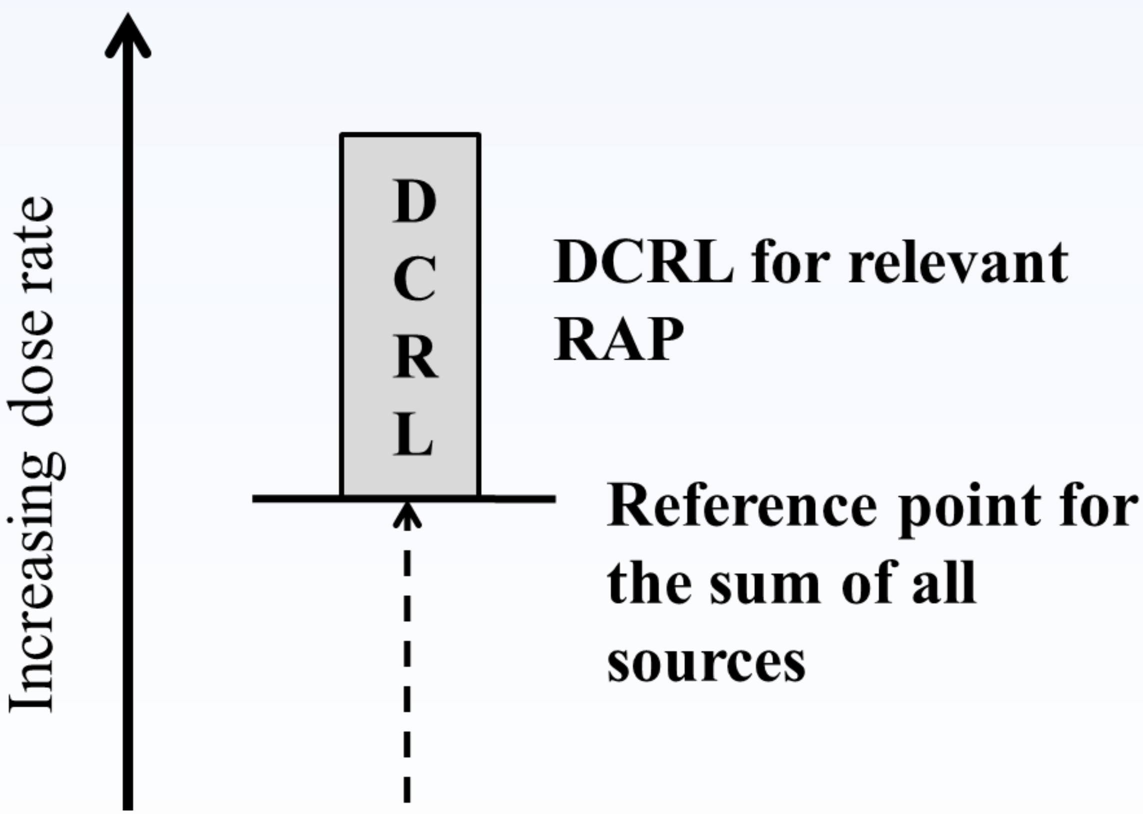
- Endpoints: mortality, morbidity, reduced reproductive success, chromosomal aberrations and mutations

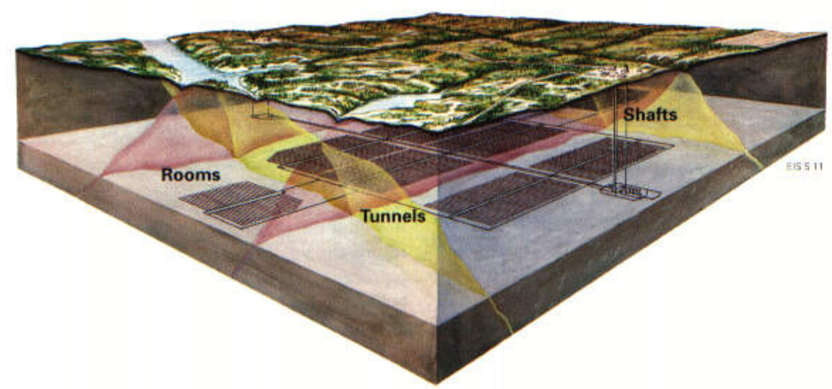
ICRP 108
Derived Consideration Reference Levels, DCRLs



ICRP 124

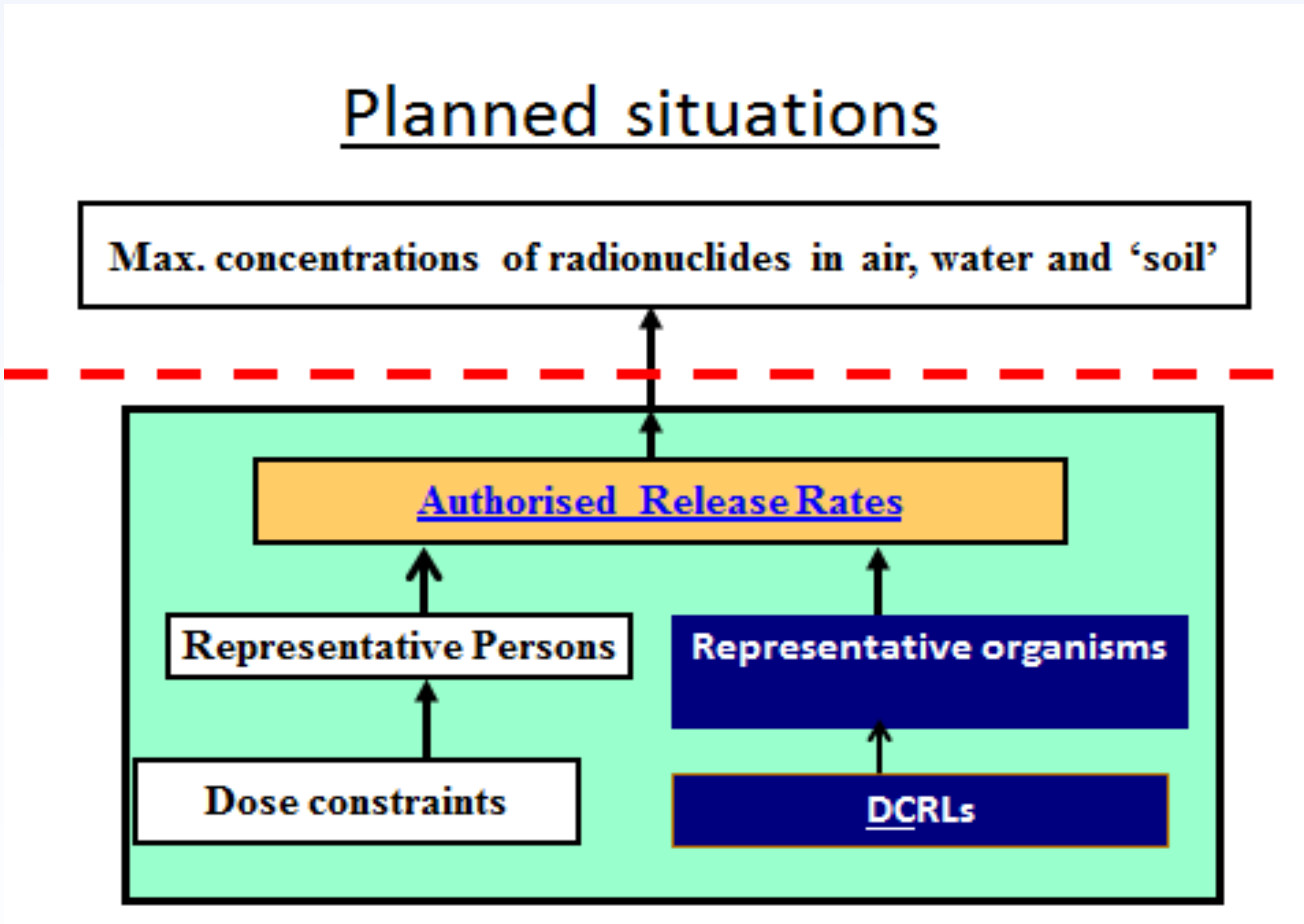
Application in planned exposure situations





ARTIST'S VIEW OF A DISPOSAL VAULT IN RELATION TO THE ROCK STRUCTURE

Application TG



This approach has been used…

OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

Agreement on a Methodology for Deriving Environmental Assessment Criteria and their application

(OSPAR Agreement: 2016-07) [1]

Introduction

1. This agreement sets out the methodology for deriving criteria for the radiological environmental assessment of concentrations of radioactive substances in the marine environment of the OSPAR maritime area by OSPAR Contracting Parties. The agreement also describes how the criteria should be applied.

2. The practical aspects of the methodology should be reviewed and updated where necessary by 2020.

Methodology

3. The methodology developed by the International Atomic Energy Agency (IAEA) for deriving the environmental assessment criteria (EAC) is set out in Reference 1 ("the IAEA Methodology") and attached at Annex 1. The principles of the IAEA Methodology were agreed by the OSPAR Radioactive Substances Committee in 2013 subject to further testing and demonstration (see 'Application' below).

4. The scheme used in the IAEA Methodology to assess the radiological impact on humans and non-humans in an integrated manner is summarised in Figure 1.

IAEA TECDOC SERIES

IAEA-TECDOC-1759

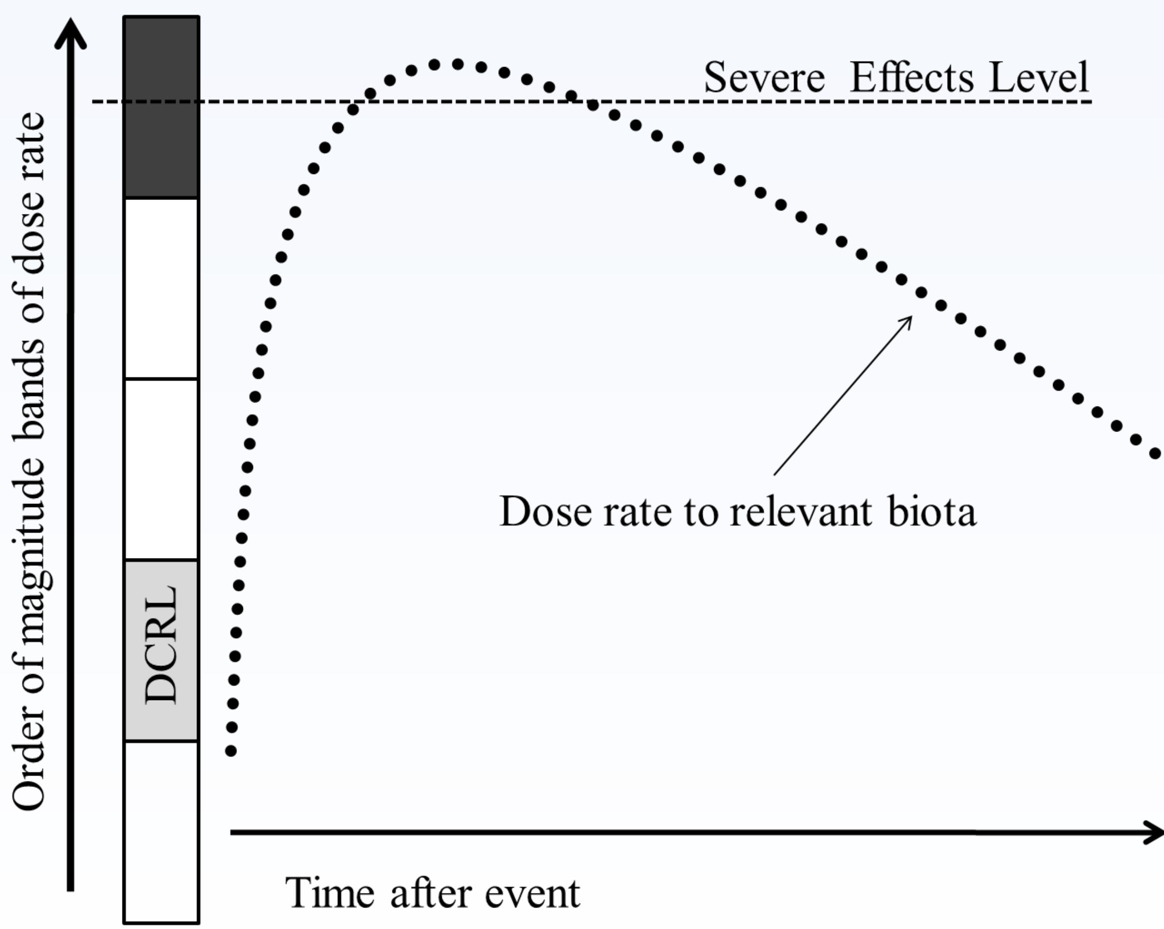
IAEA-TECDOC-1759

Determining the Suitability of Materials for Disposal at Sea under the London Convention 1972 and London Protocol 1996: A Radiological Assessment Procedure

IAEA
International Atomic Energy Agency

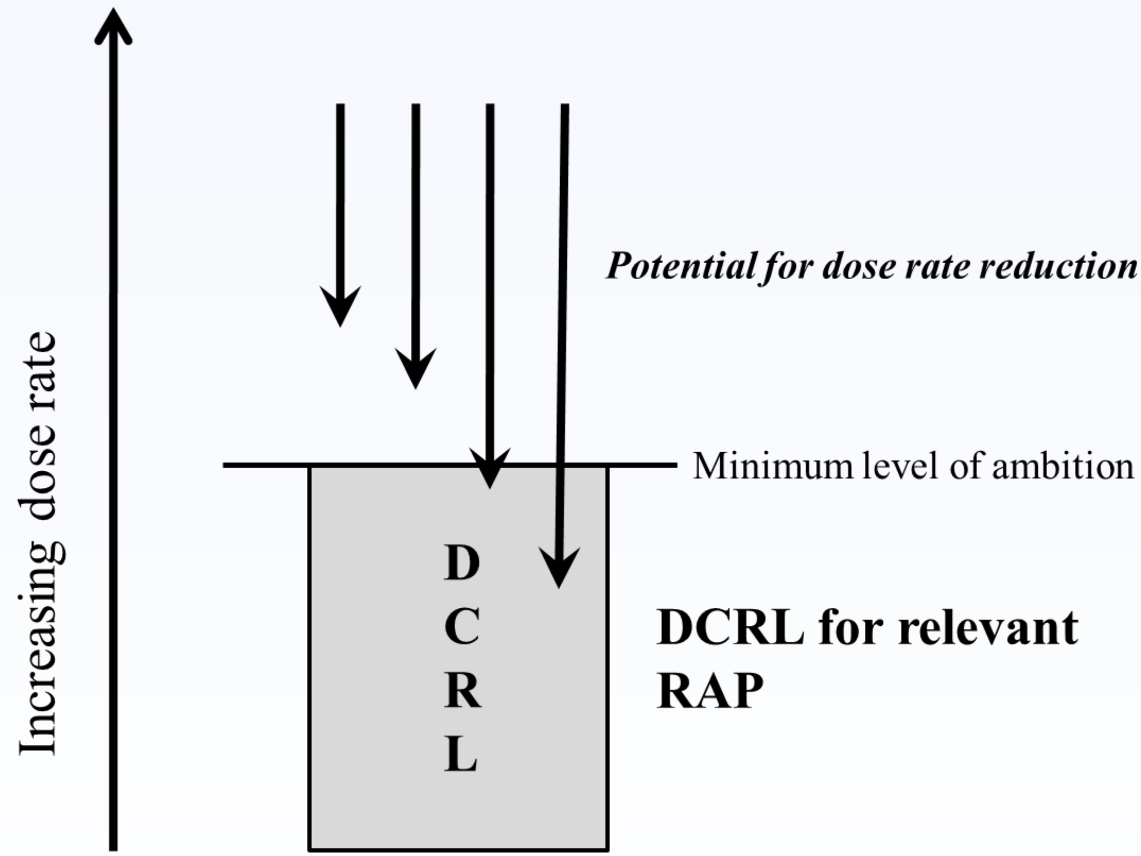
ICRP 124

Application in emergency exposure situations



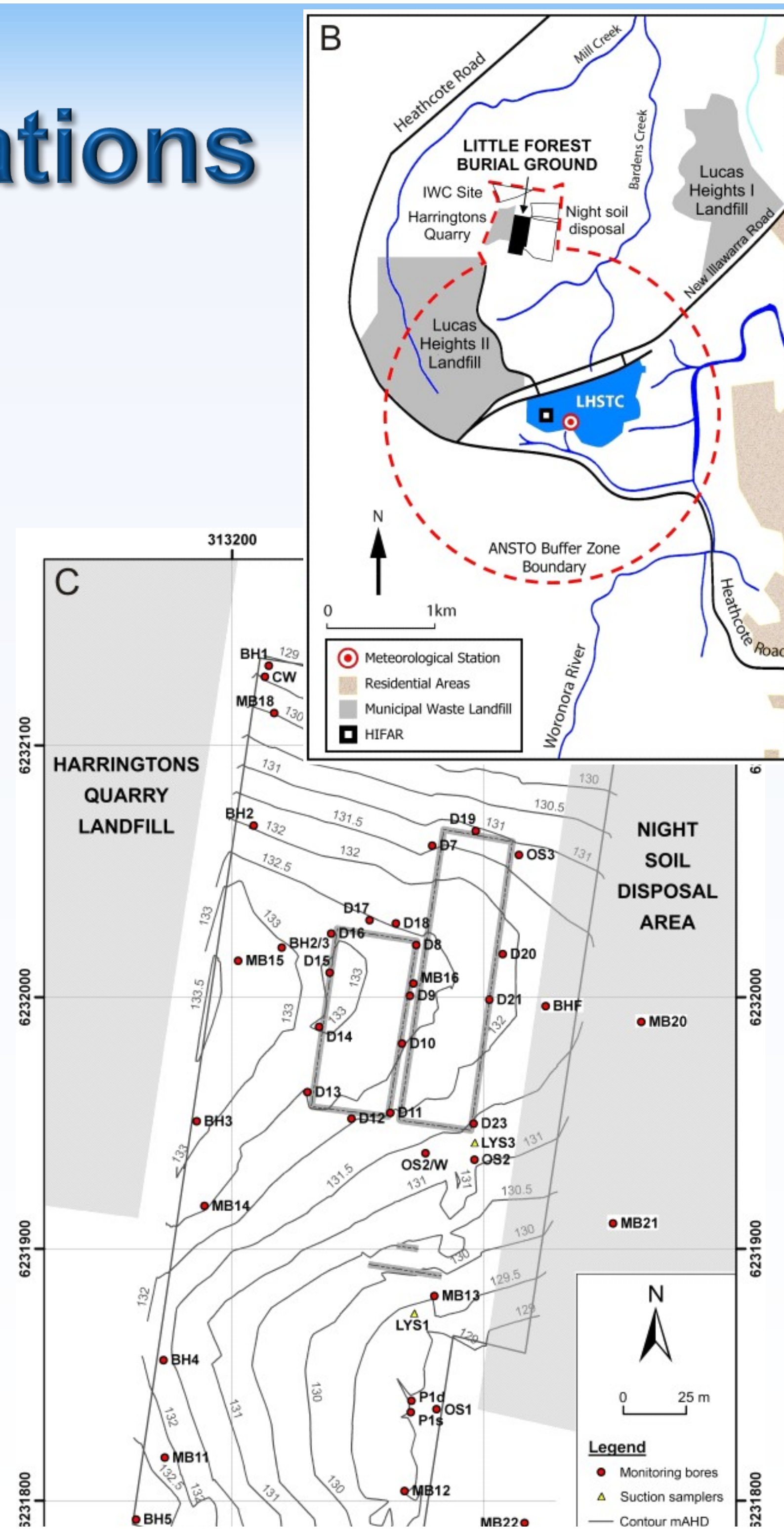
ICRP 124

Application in existing exposure situations



Existing exposure situations

- New Task Group planned (under consideration within ICRP)
- Specific task to look at radiological v non-radiological impacts of remediation option using examples
- E.g. Little Forest Burial Ground, Australia
  - All human exposure scenarios below 1 mSv
  - Reference values not required to be set
  - Wildlife considered with most being below relevant DCRL
  - But… frog larvae and tree assessments highlighted potential to exceed the relevant DCRL
  - Spatial and temporal extent may need to be considered
  - Long term management needs to consider wildlife….



What do you consider?

- The nature of the exposure situation – normal, existing, or emergency;
- the area or zone (km^2) within which such dose rates were assessed to occur;
- the time period predicted for such dose rates;
- the principal reason for the assessment being made, such as the need to comply
- with some form of existing legislation;
- the type of managerial interest, such as fisheries management, agriculture, nature conservation, habitat protection, etc.;

What do you consider?

- The presence, or expected presence, of additional sources of chemicals, or other
- forms of environmental stress, in the same area;
- whether or not the assessment related to actual species, or simply to generalised animal or plant types; and
- the degree of precaution considered necessary for various purposes.

What remains?

- Ecological offsetting (a common mitigation measure)
- Post accident – communication issues and the emphasis will always remain on human radiological protection
- Existing exposure - the aim is to try to ensure that any remediation/optimisation has a positive effect on both wildlife and humans e.g.

ELSEVIER
Journal of Environmental Radioactivity 83 (2005) 383–397
RADIOACTIVITY
www.elsevier.com/locate/jenvrad

Identifying optimal agricultural countermeasure strategies for a hypothetical contamination scenario using the strategy model

G. Cox [a], N.A. Beresford [b], B. Alvarez-Farizo [c], D. Oughton [d], Z. Kis [e], K. Eged [e], H. Thørring [f], J. Hunt [g], S. Wright [b], C.L. Barnett [b], J.M. Gil [c], B.J. Howard [b], N.M.J. Crout [a,*]

Application TG?

Representative Organism:
A typical organism representative of its environment (kangaroo).

Reference Animal:
A numerical approximation of organisms within a certain group of wildlife (large herbivorous mammal)

[ARPANSA Safety Guide SG-1(draft 2015)]

Challenges

Effects at Chernobyl

20 August 2010 Last updated at 10:17

Chernobyl species decline linked to DNA

By Victoria Gill
Science reporter, BBC News

The scientists have studied the exclusion zone for more than a decade

Scientists working in Chernobyl have found a way to predict which species there are likely to be most severely damaged by radioactive contamination.

The secret to a species' vulnerability, they say, lies in its DNA.

This discovery could reveal which species are most likely to decline or even become extinct in response to other types of environmental stress.

The researchers published their findings in the Journal of Evolutionary Biology.

Related stories

Mammals decline in Chernobyl zone

v's

Last Updated: Thursday, 20 April 2006, 05:55 GMT 06:55 UK

E-mail this to a friend   Printable version

Wildlife defies Chernobyl radiation

By Stephen Mulvey
BBC News

It contains some of the most contaminated land in the world, yet it has become a haven for wildlife - a nature reserve in all but name.

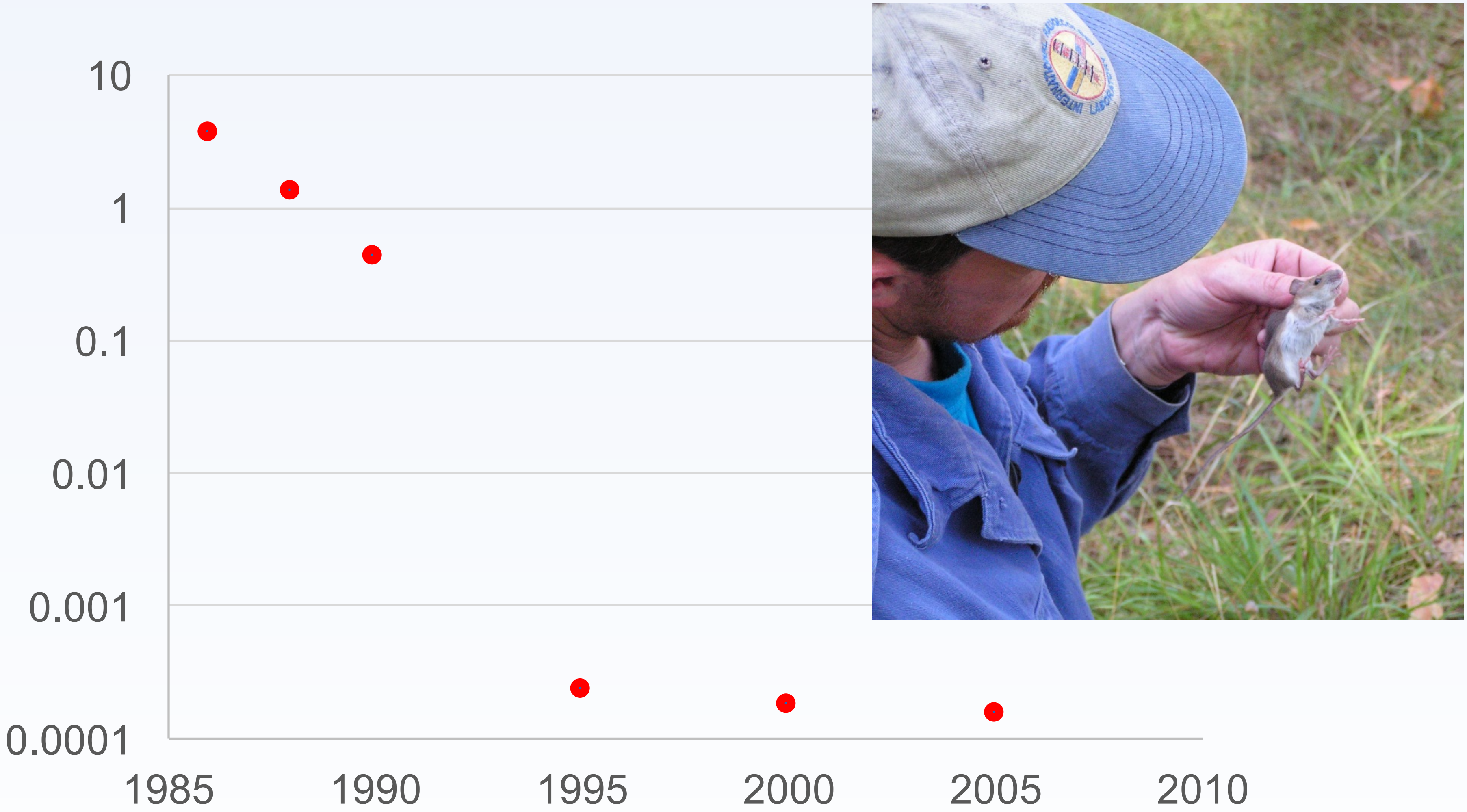
The exclusion zone around the Chernobyl nuclear power station is teeming with life.

As humans were evacuated from the area 20 years ago, animals moved in. Existing populations multiplied and species not seen for decades, such as the lynx and eagle owl, began to return.

There are even tantalising footprints of a bear, an animal that has not trodden this part

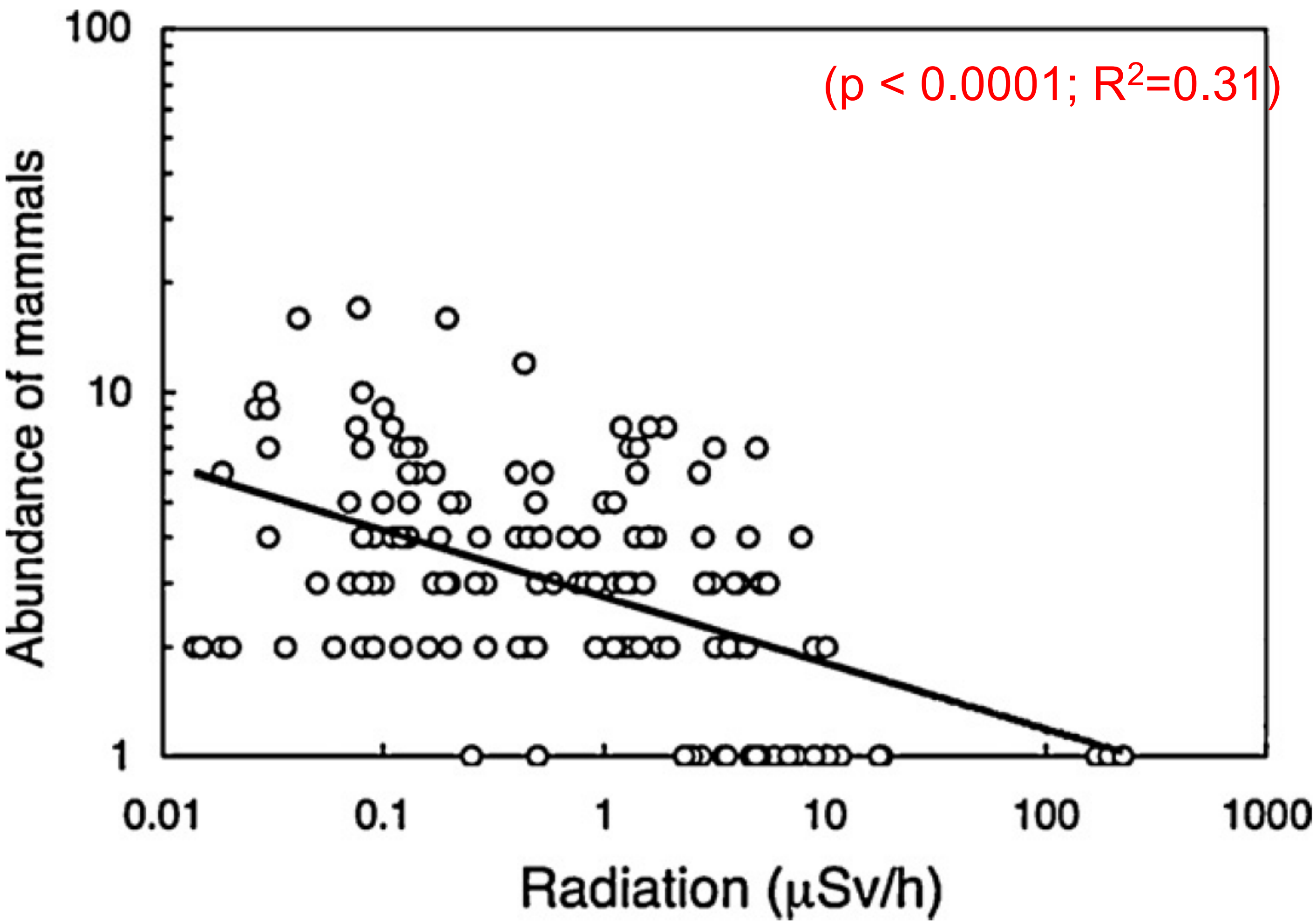
BBC website

Mammals



Estimated absorbed dose rate (Gy/h) to small mammals in Red Forest (Gaschak et al. 2011, Health Physics)

Mammals

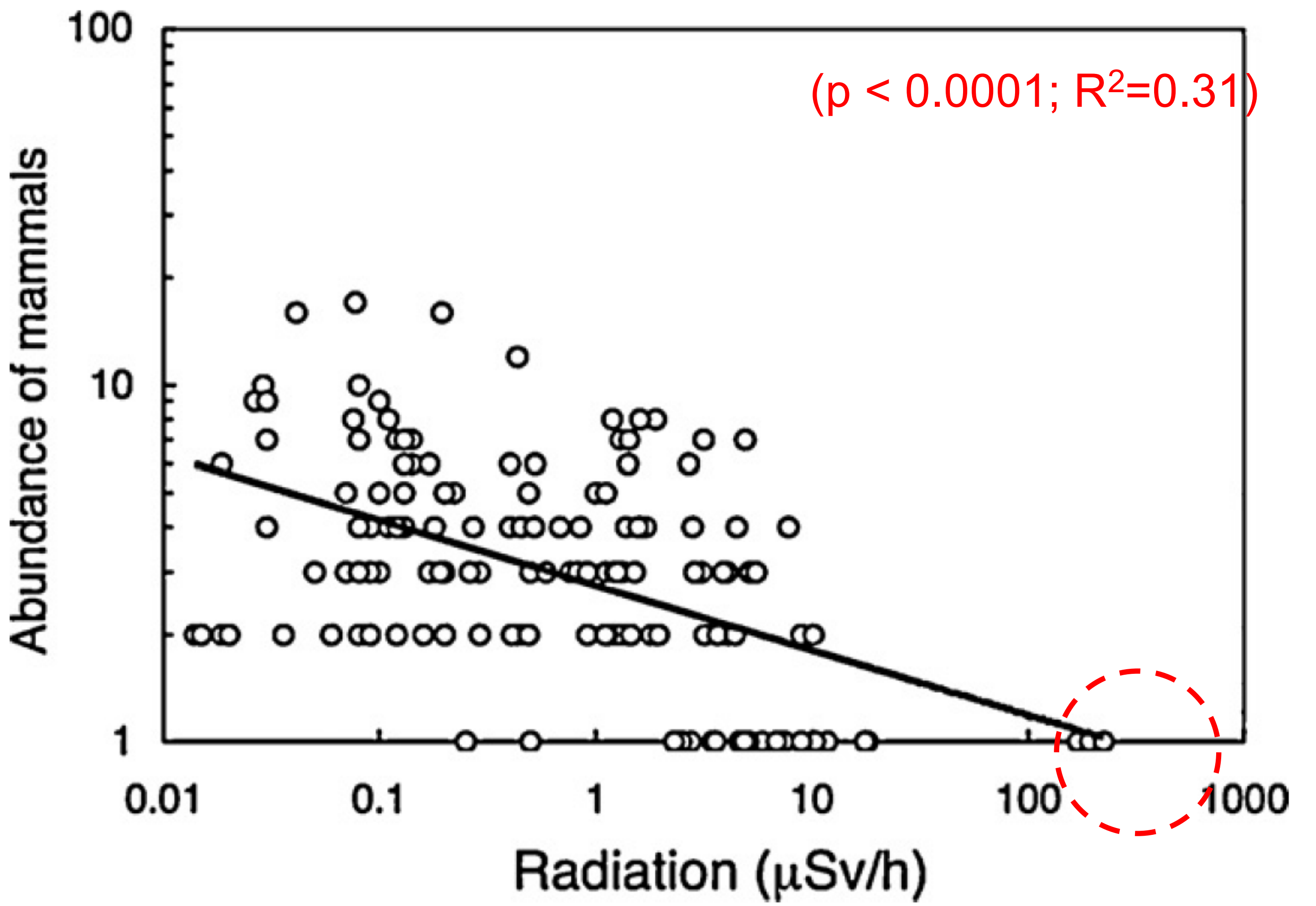


12 species

Dose meter measurement at ground level
(2-3 measurements per transect?)

Moller & Mousseau 2013

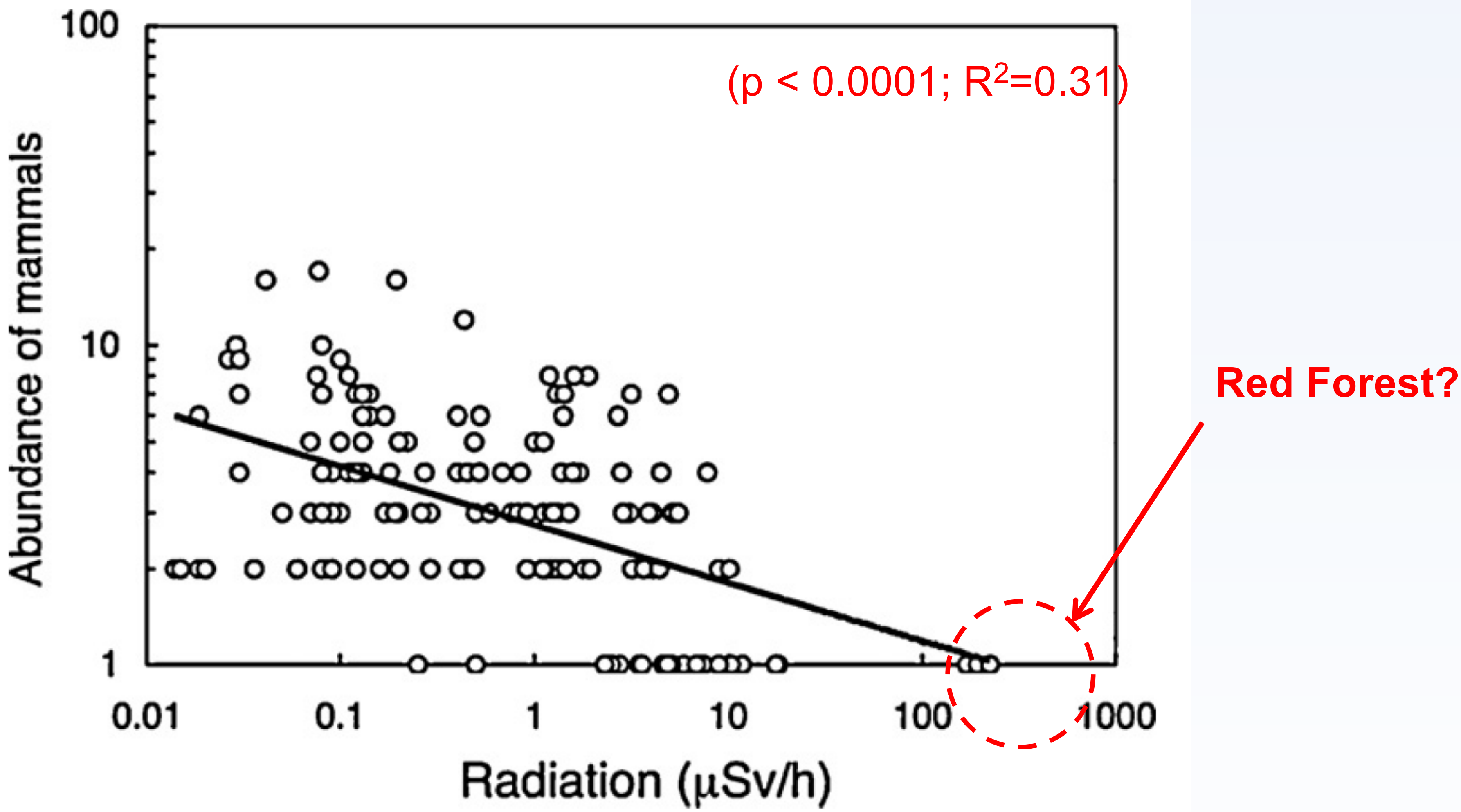
Mammals



Dose meter measurement at ground level
(2-3 measurements per transect?)

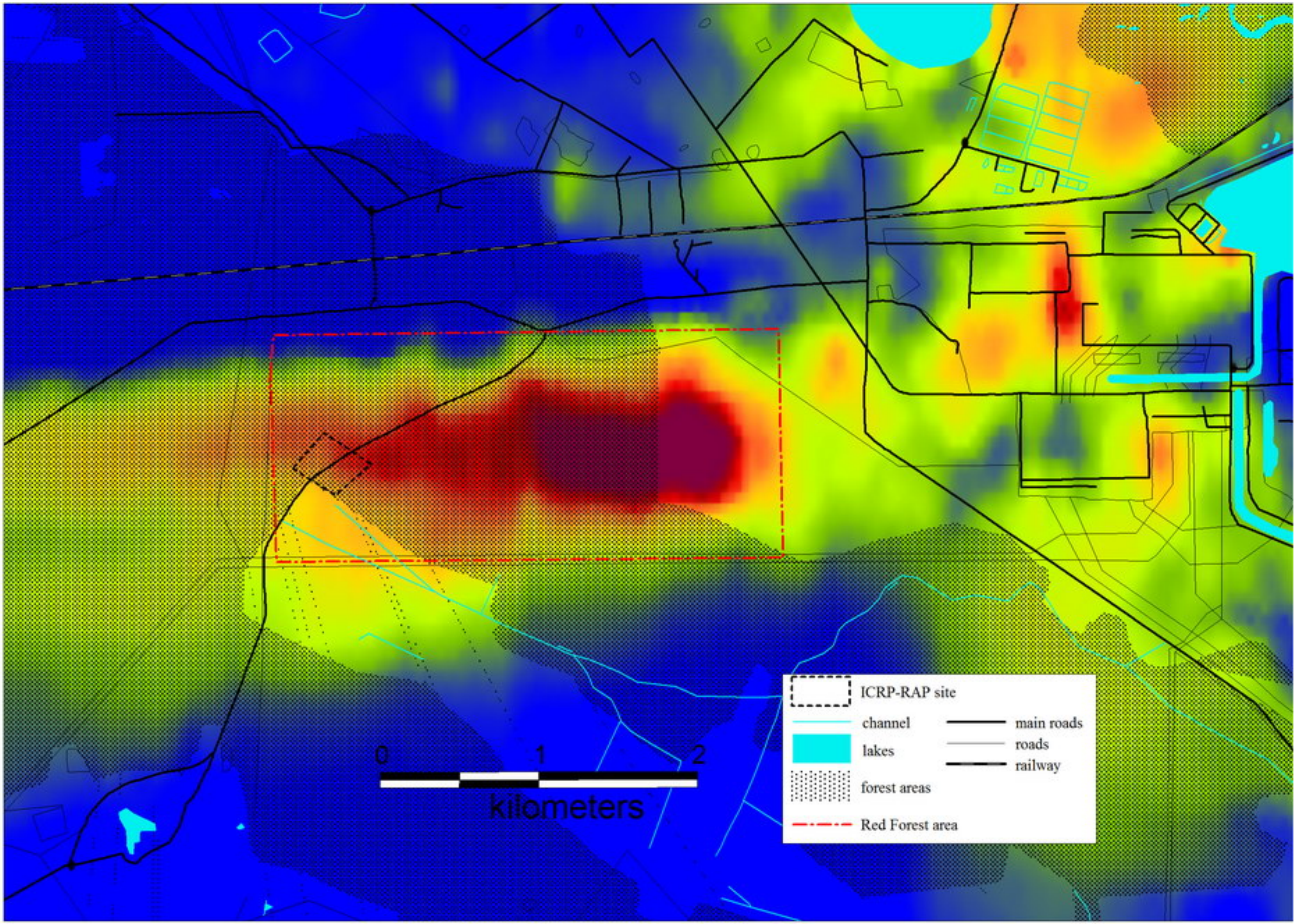
Moller & Mousseau 2013

Mammals



Dose meter measurement at ground level
(2-3 measurements per transect?)

Moller & Mousseau 2013


ICRP-RAP site
channel
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forest areas
Red Forest area
main roads
roads
railway
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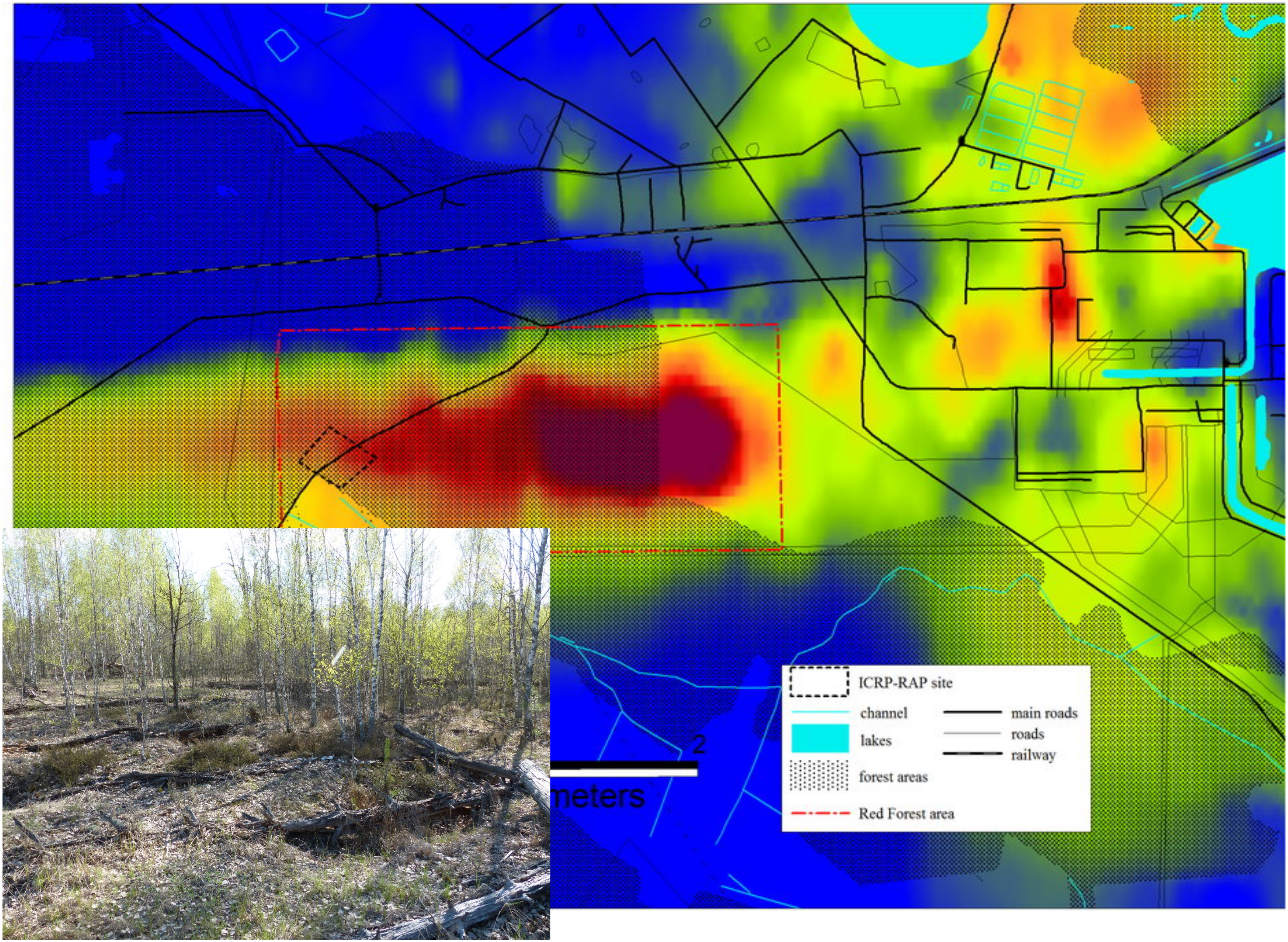
kilometers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main roads
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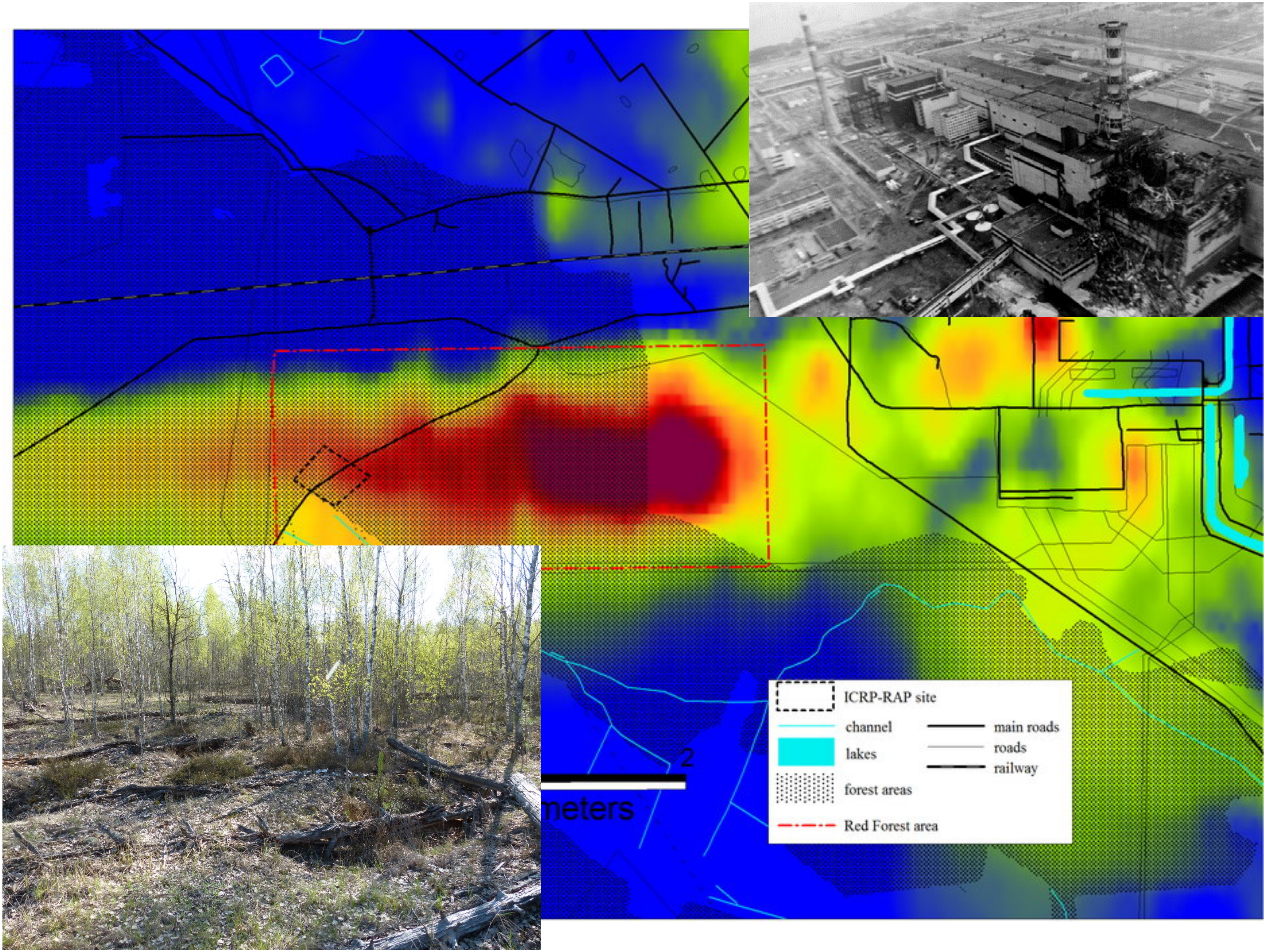
railway


ICRP-RAP site
channel
lakes
forest areas
Red Forest area
main roads
roads
railway
2
meters

Invertebrates

1986:

Pine forest 3 km from NPP

- 30-fold reduction soil dwelling mites (29 Gy)
- Larvae/nymphs of many species absent

Agricultural soils 3-7 km from NPP

- Lower abundance of young earthworms

1988/89:

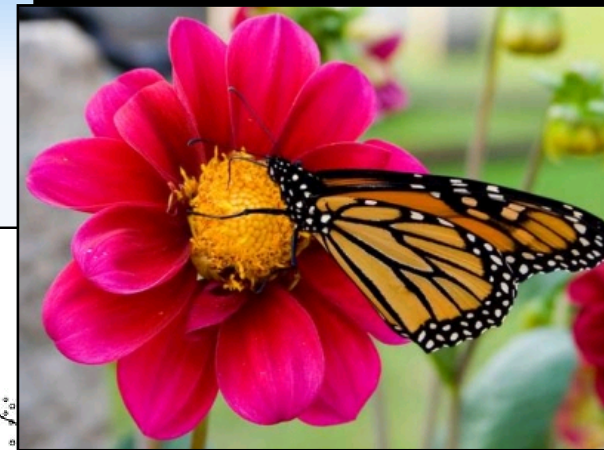
- Mesofauna population size restored

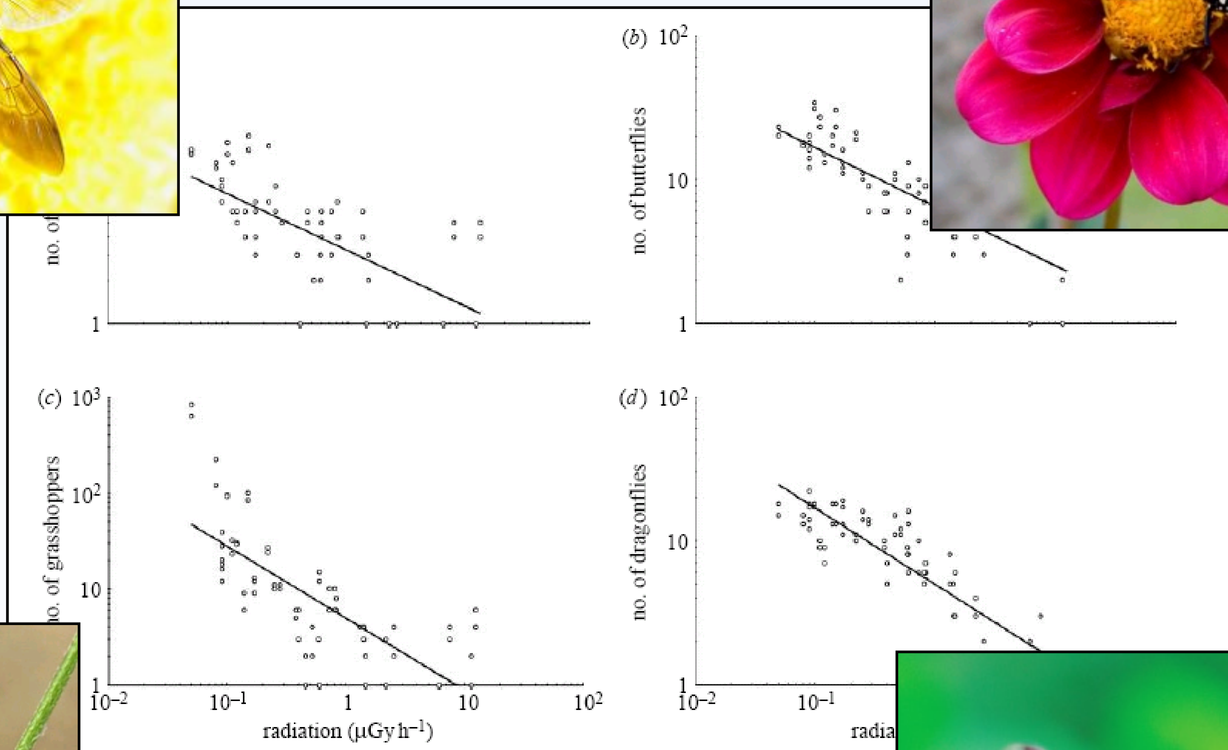
Mid-1990's:

- Changes in species composition as consequence of changing ecosystems
- Reduced mesofauna diversity

Geras'kin et al. 2008. Environment International

Invertebrates

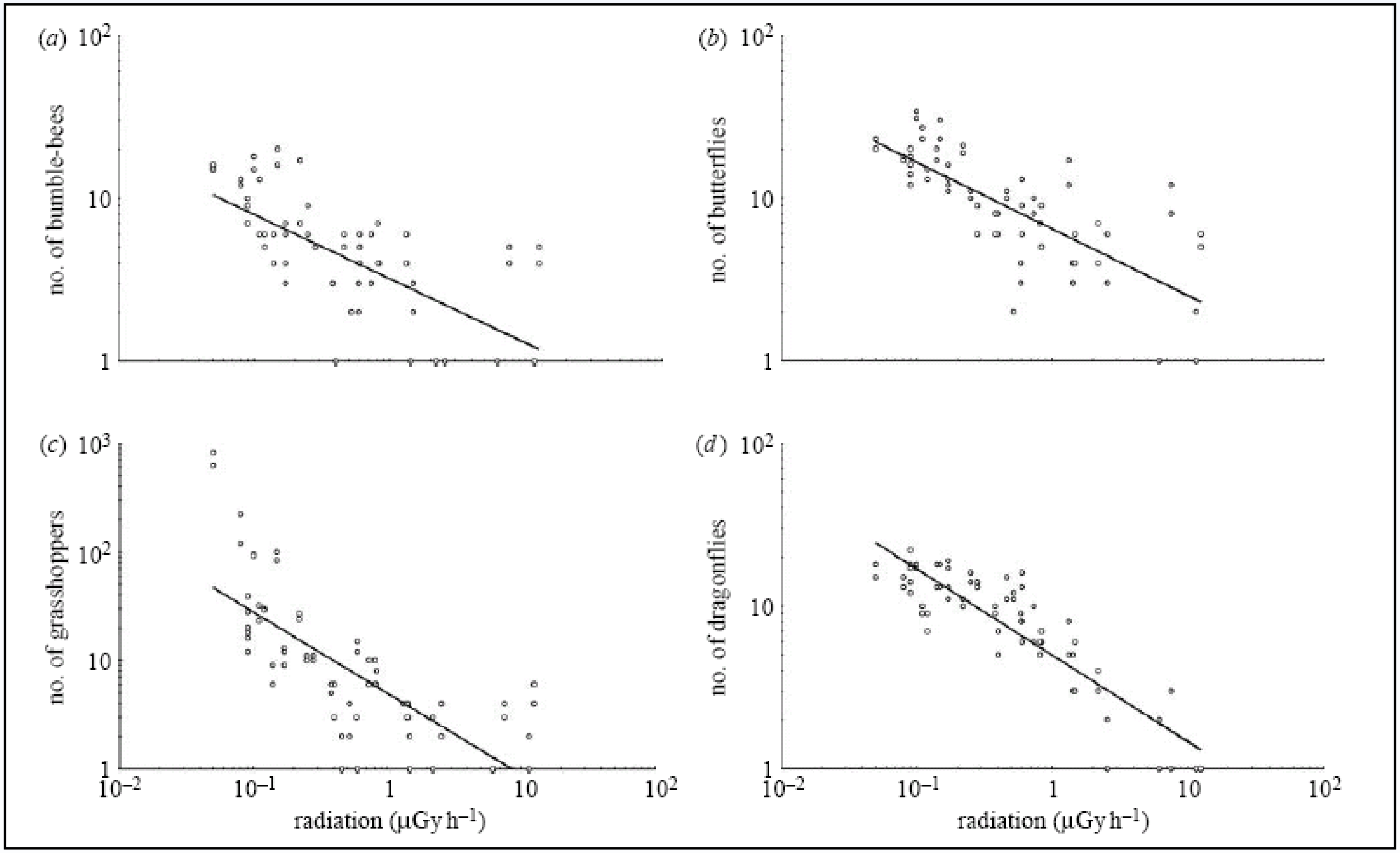




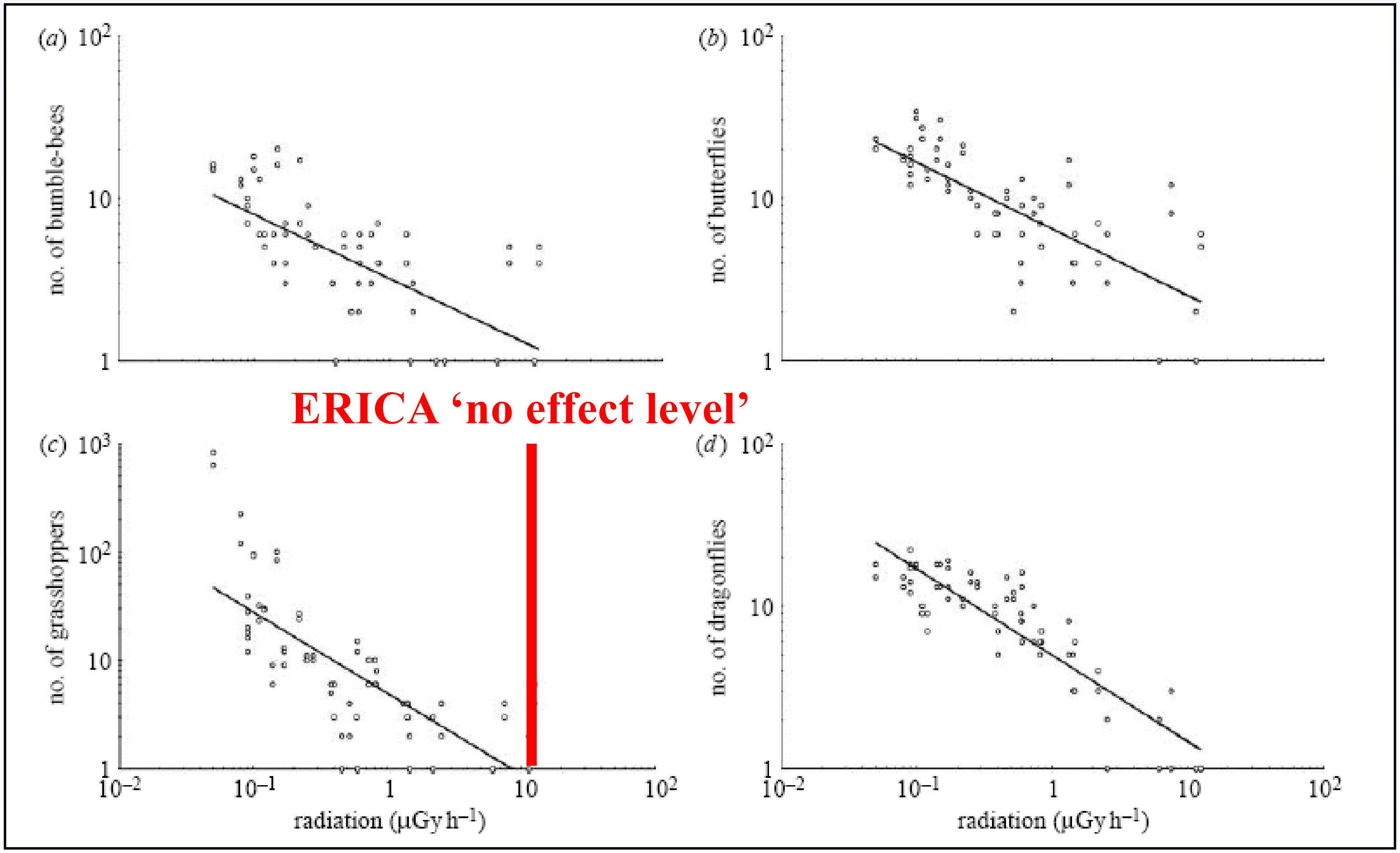
Chernobyl

Møller & Mousseau 2009

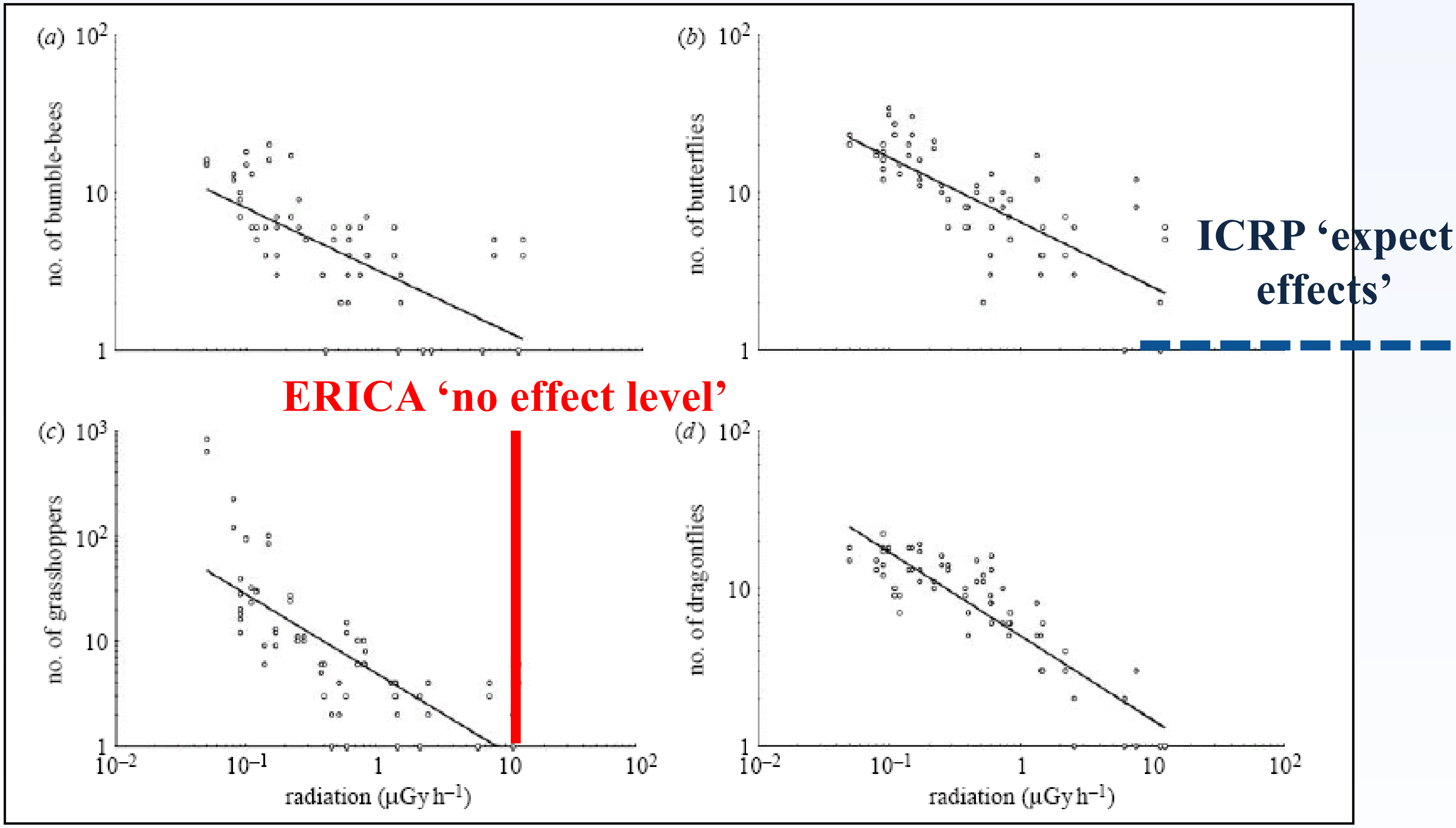
Biol. Lett.



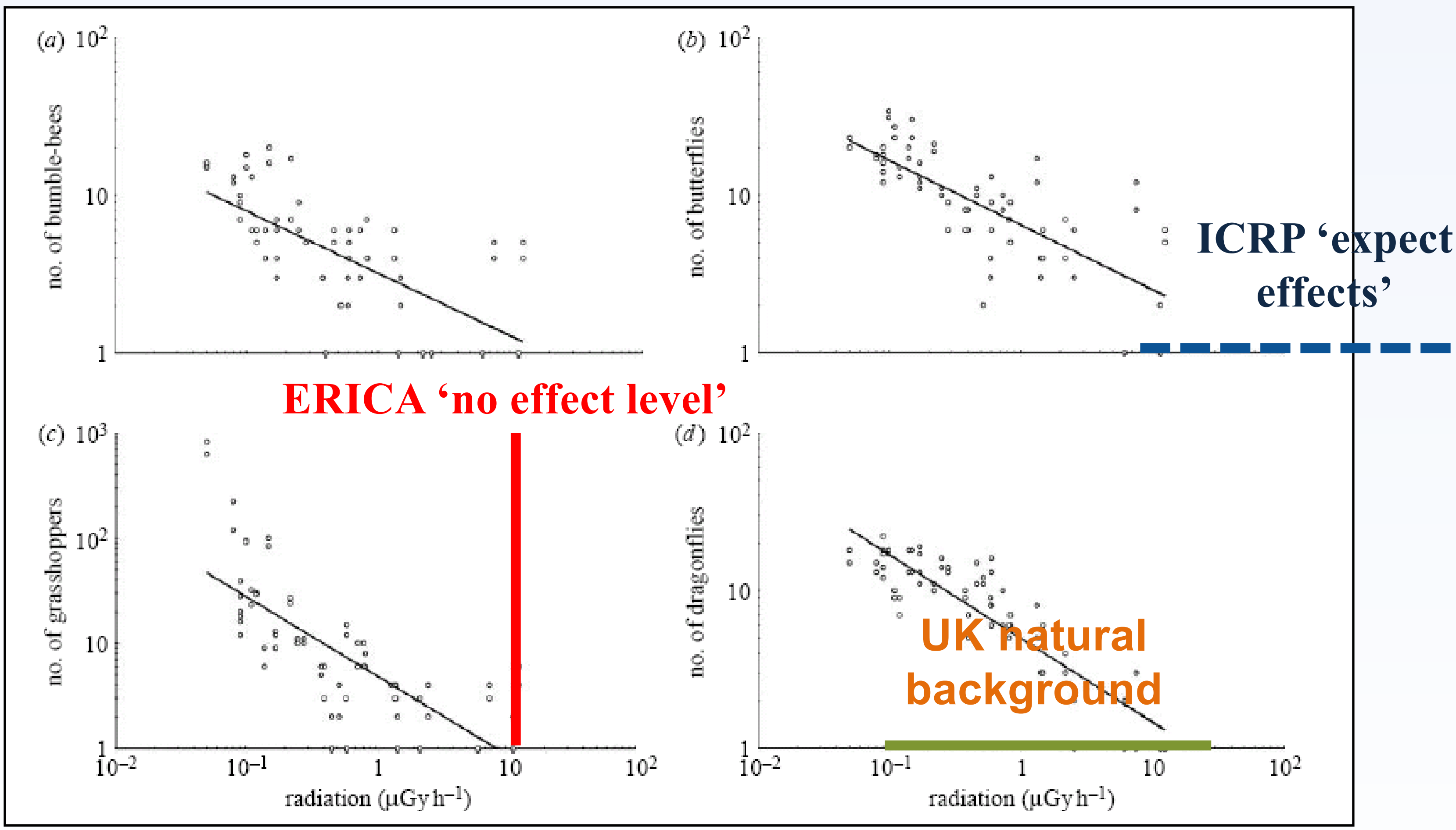
(a)
no. of bumble-bees
(b)
no. of butterflies
(c)
no. of grasshoppers
(d)
no. of dragonflies
radiation (μGy h−1)
radiation (μGy h−1)



(a)
no. of bumble-bees
(b)
no. of butterflies
ERICA 'no effect level'
(c)
no. of grasshoppers
(d)
no. of dragonflies
radiation (µGy h−1)
radiation (µGy h−1)



ICRP 'expect effects'
ERICA 'no effect level'
(a)
no. of bumble-bees
(b)
no. of butterflies
(c)
no. of grasshoppers
(d)
no. of dragonflies
radiation (μGy h−1)
radiation (μGy h−1)

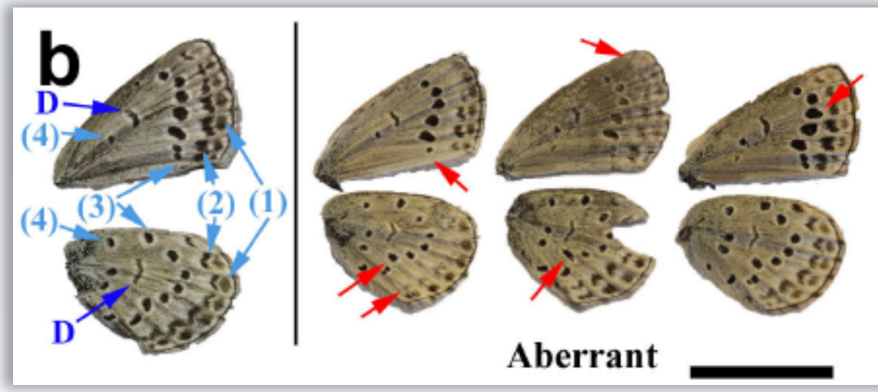


ICRP 'expect effects'
ERICA 'no effect level'
UK natural background
(a)
no. of bumble-bees
(b)
no. of butterflies
(c)
no. of grasshoppers
(d)
no. of dragonflies
radiation (μGy h−1)
radiation (μGy h−1)

Post-March 11 reports

Phenotypic modification in butterflies

Hiyama et al, Sci. Rep. 2, 570; DOI:10.1038/srep00570 (2012)



Loss of leader shoot in Japanese fir trees

Sci. Rep. 5, 13232; DOI: 10.1038/srep13232 (2015)

Population impact on barn swallows

Scientific American Feb 2015


NUCLEAR FALLOUT

The Swallows of Fukushima

We know surprisingly little about what low-dose radiation does to organisms and ecosystems. Four years after the disaster in Fukushima, scientists are beginning to get some answers

Japan butterflies

- **Butterfly larvae fed plants harvested from Fukushima evacuated area**
- **LD_{50} = 1.9 Bq**

Hiyama et al. 2014, *Scientific Reports*

Japan butterflies

- **Butterfly larvae fed plants harvested from Fukushima evacuated area**
- **LD_{50} = 1.9 Bq**
- **LD_{50} equates to a maximum of *c.* 8µGy/h**
  - Below ‘no-effect’ and in natural background range?

Comment by Copplestone & Beresford, 2014, *The Conversation*

Japan butterflies

- **Butterfly larvae fed plants harvested from Fukushima evacuated area**
- **LD_{50} = 1.9 Bq**
- **LD_{50} equates to a maximum of *c*. 8μGy/h**
  - Below 'no-effect' and in natural background range?
- **From previous studies LD_{50} for sub-adults ≥ 1 Gy**

Dose rates, Okuma Town, June 2011

RAP	Dose-rate estimate	Lower end DCRL	Ratio of estimate to benchmark
	µGy/h		
Bee	18	400	0.04
Deer	71	4	17.8
Duck	21	4	5.3
Earthworm	46	400	0.11
Frog	18	40	0.45
Pine tree	17	4	4.3
Rat	46	4	11.5
Wildgrass	26	40	0.65

[UNSCEAR 2013, Vol I, Scientific Annex A]

Summary

- A robust system has evolved that is for humans and the environment
- There are differences and similarities when actually undertaking assessments
- Considering the environment in its own right is appropriate and facilitates communication
- Further advice and recommendations are still being developed but there is enough information to apply the one system of radiological protection now

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