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Protection of the Environment

Where is the radiation protection world today and what lies ahead?

David Copplestone

BE THE DIFFERENCE

Policy drivers/new technologies etc.

Low carbon transition requirements (440 plants plus 50 under construction)

Radioactive waste disposal solutions

Isotopes with new medical applications

Merging of cancer treatment centres

Conservation drivers

Public confidence and high media interest

BBC David News Sport Weather iPlayer Sounds

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Science & Environment

Final call to save the world from 'climate catastrophe'

By Matt McGrath
Environment correspondent, Incheon, South Korea

8 October 2018 Share

Climate change: How 1.5 degrees could change the world

It's the final call, say scientists, the most extensive warning yet on the risks of rising global temperatures.

ICRP Publication 103

2. THE AIMS AND SCOPE OF THE RECOMMENDATIONS

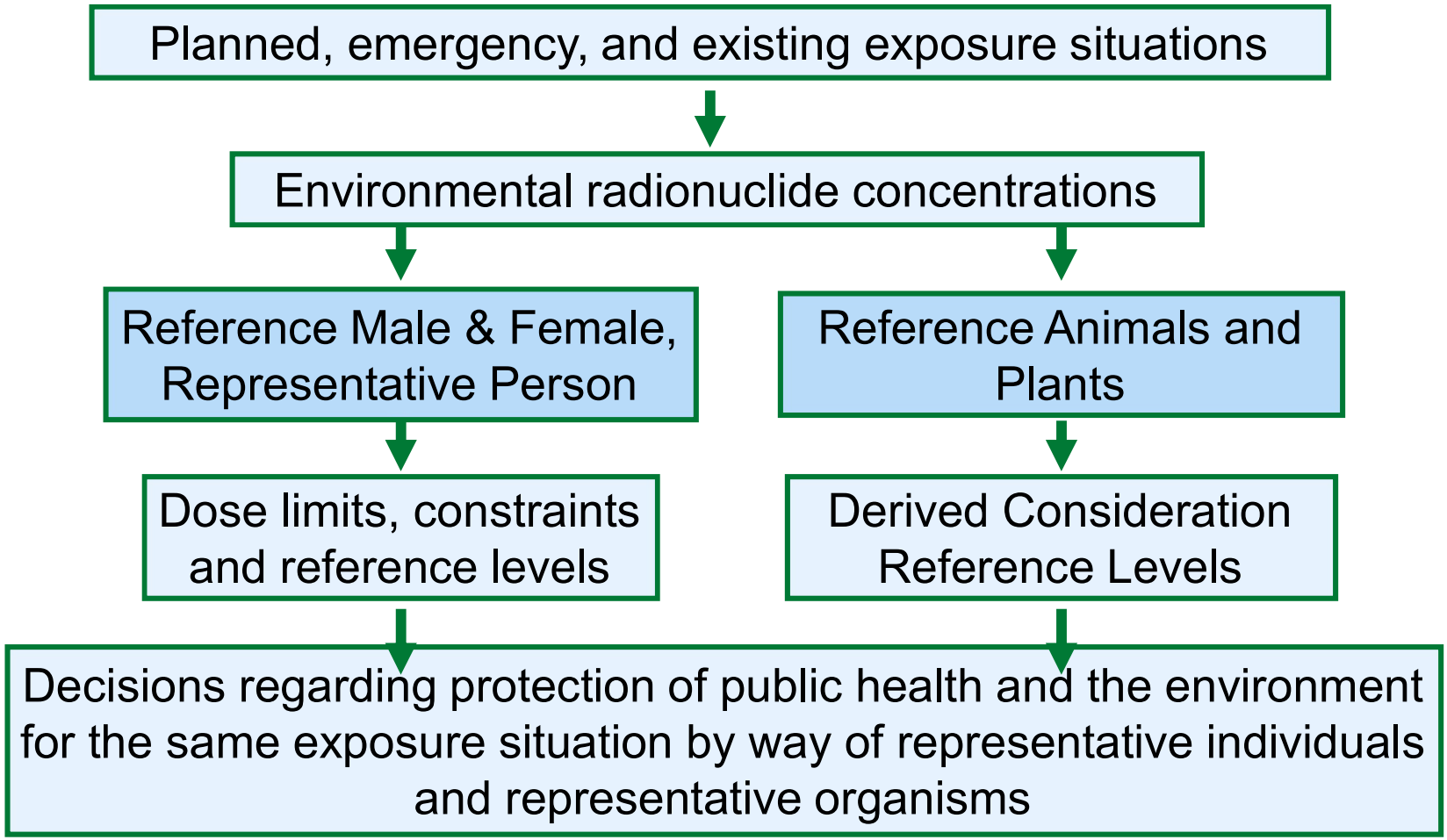
(26) The primary aim of the Commission's Recommendations is to contribute to an appropriate level of protection for **people and the environment** against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure.

ICRP Publication 103

(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.....

Radiological Protection System



[*Publication 108*]

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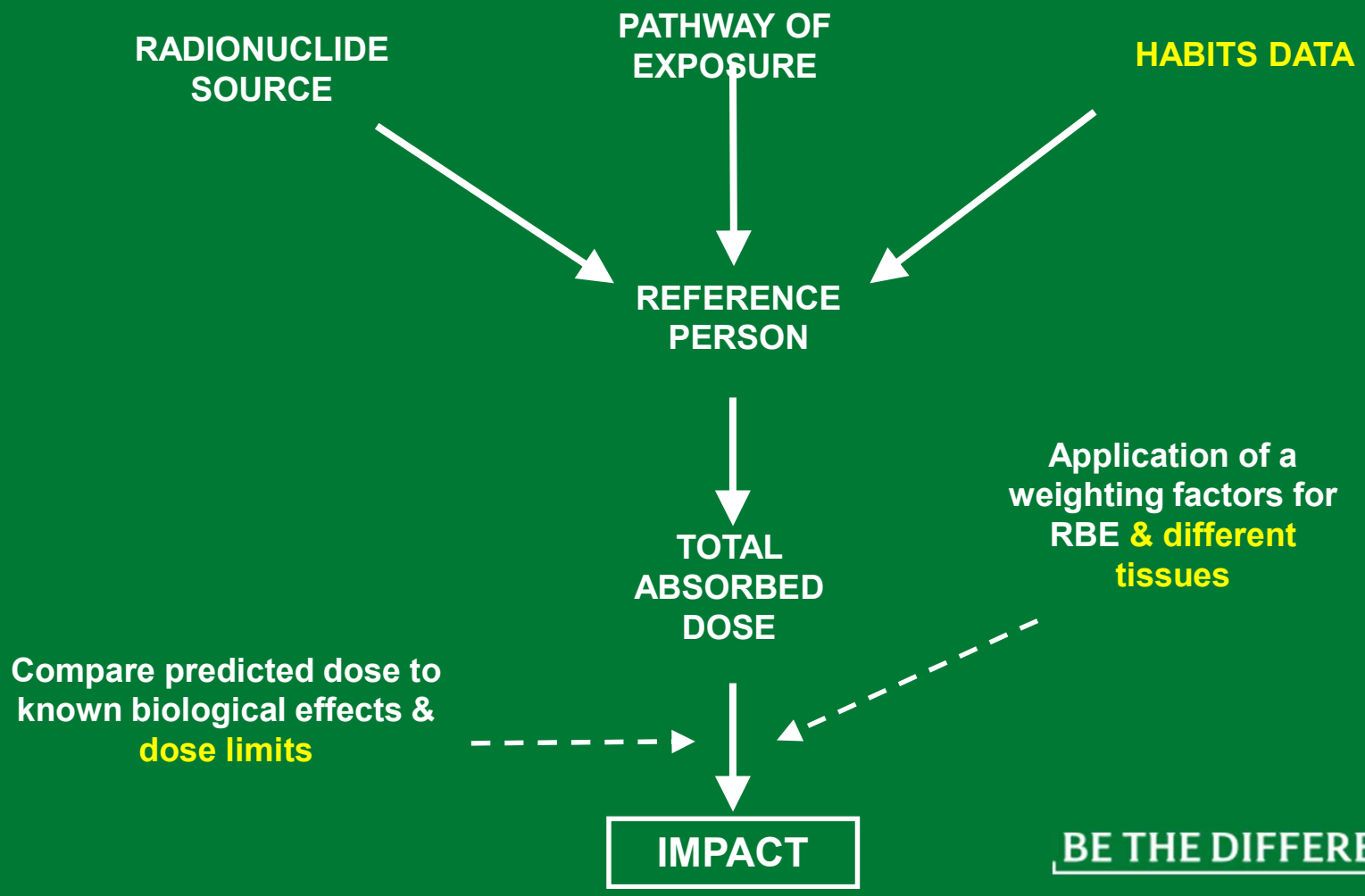
Simplified human assessment



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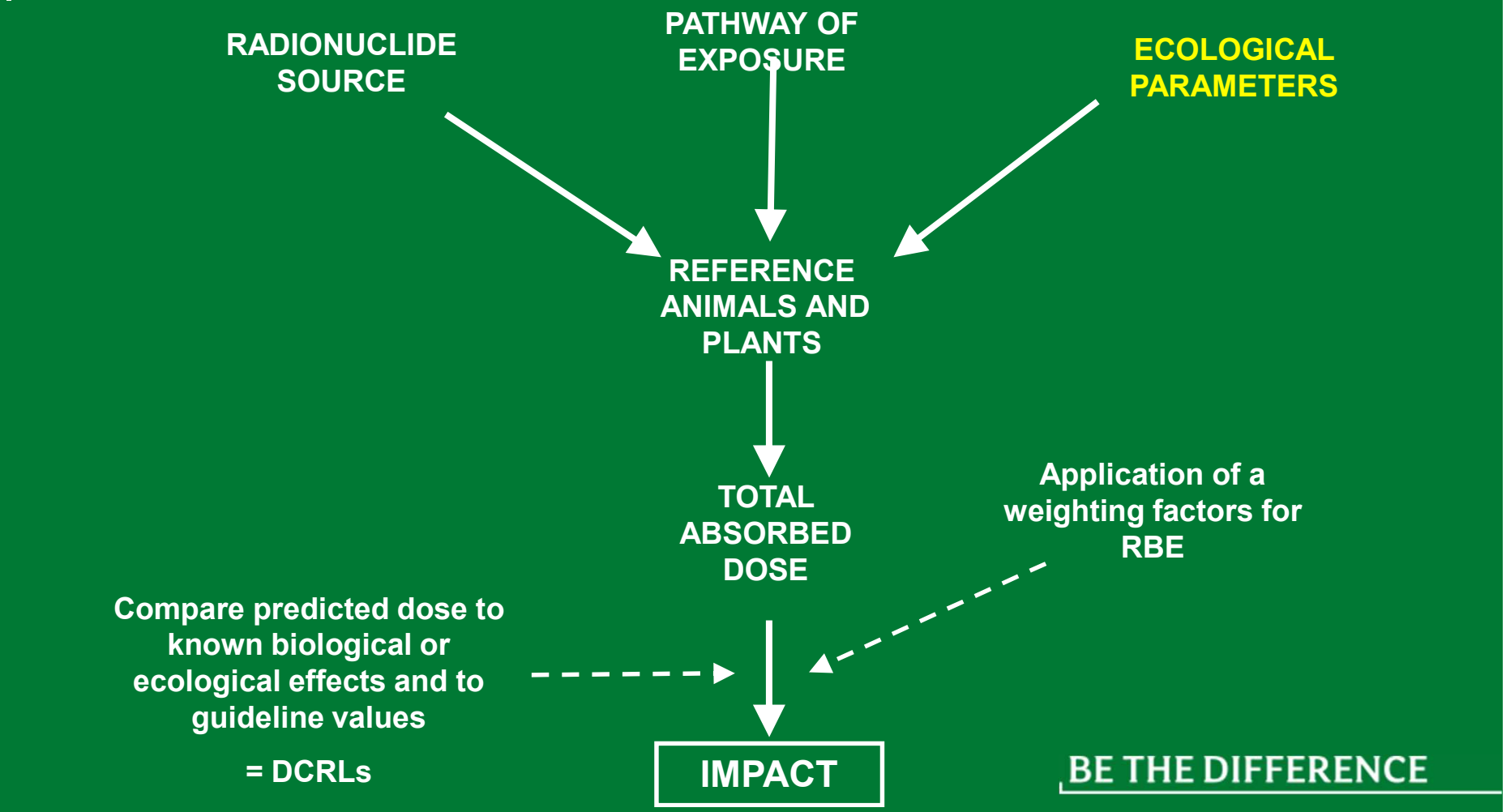
Simplified non-human assessment



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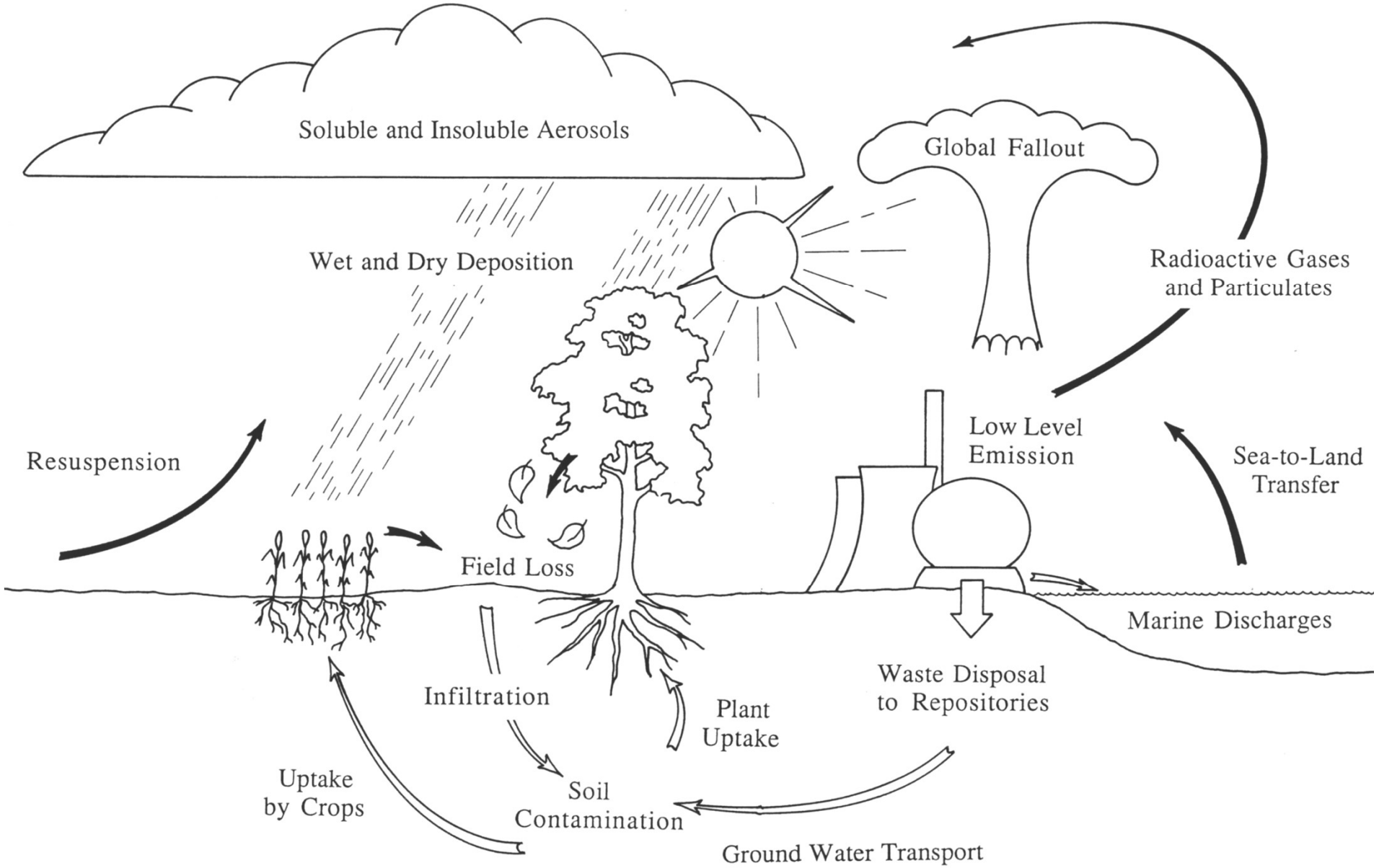
Transfer


Soluble and Insoluble Aerosols
Global Fallout
Wet and Dry Deposition
Radioactive Gases
and Particulates
Resuspension
Low Level
Emission
Sea-to-Land
Transfer
Field Loss
Marine Discharges
Infiltration
Waste Disposal
to Repositories
Plant
Uptake
Uptake
by Crops
Soil
Contamination
Ground Water Transport

Transfer

Not integrated between human and wildlife

Underpinning databases are different

Things to consider

Livestock are not generally considered within environmental protection assessments (are they protected by the human assessments?)

Potential issues

Non-equilibrium situations

Missing information

Different methods for deriving (missing) parameters

e.g. REML work

Dosimetry

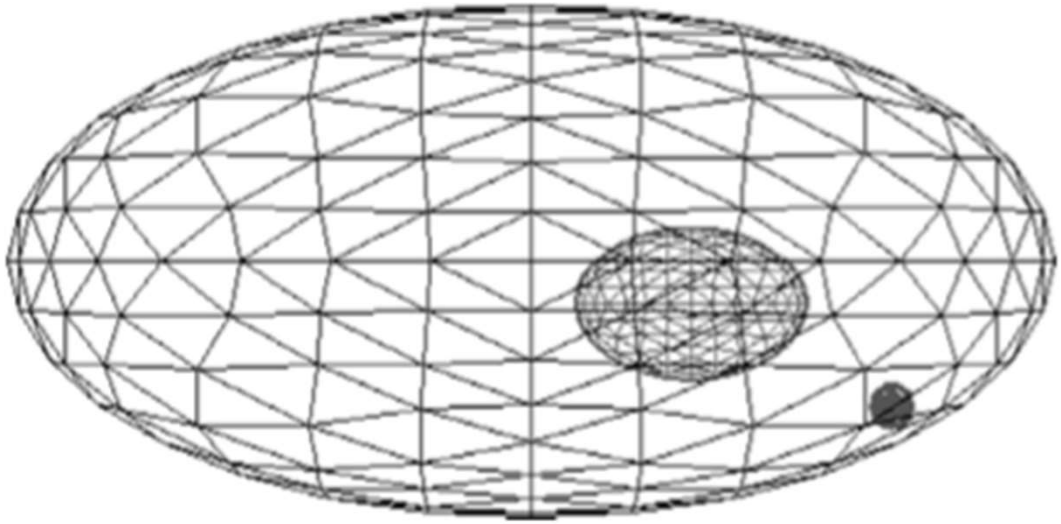
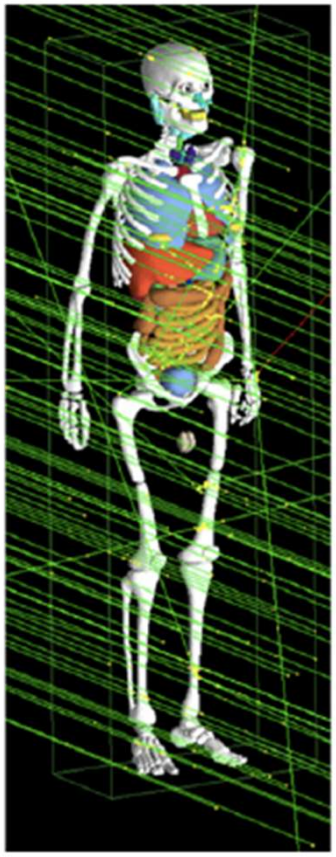
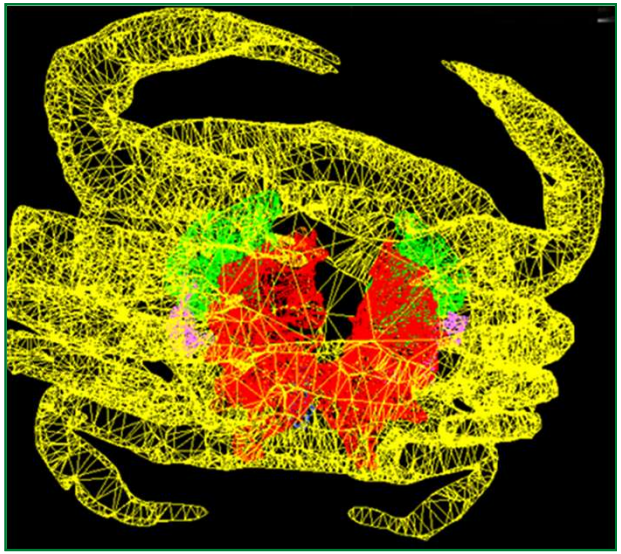
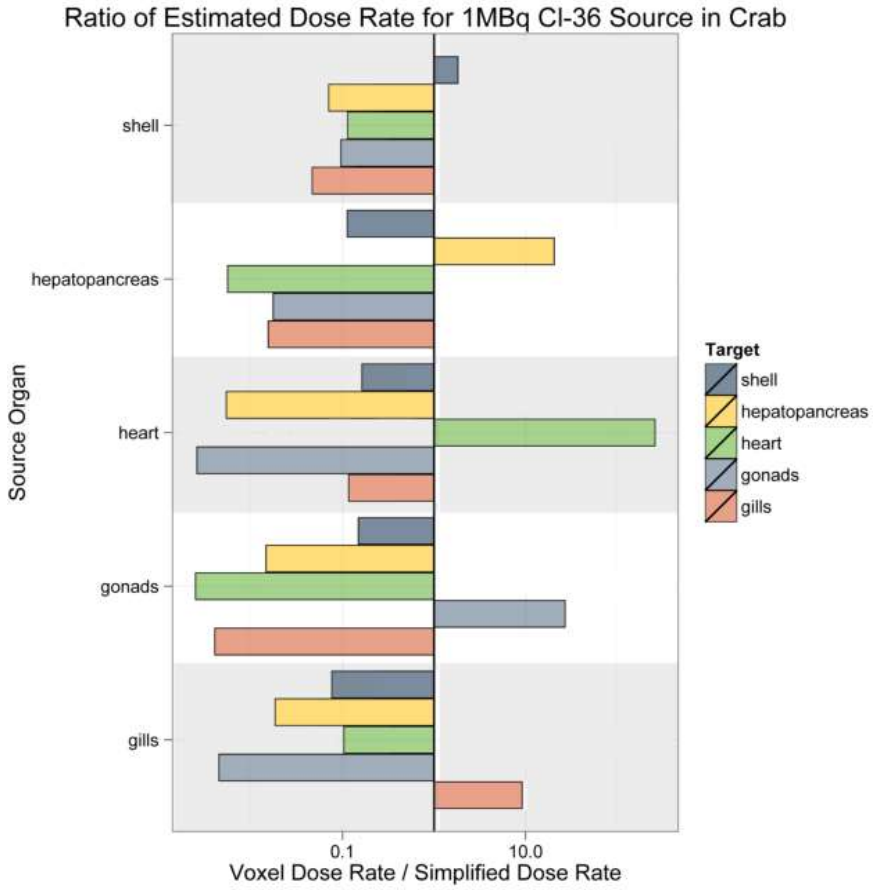


Fig. 4.4. Geometrical model of deer body with liver (large inner ellipsoid) and testes (small inner ellipsoid).

Dosimetry







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

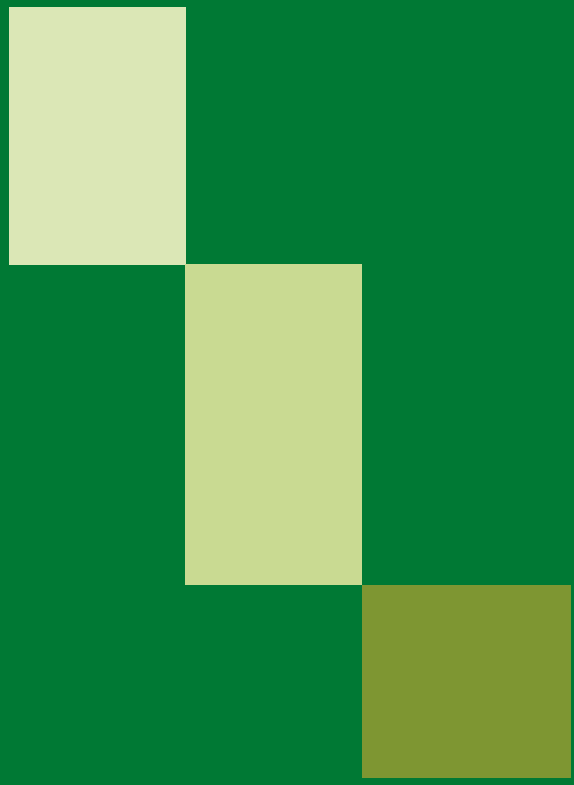
Not for regulation!

Testing models – are they fit for purpose?

Improved understanding of dose delivery

Dose-response relationships (effects)

Wildlife group	Ecosystem[1]	RAP
Large terrestrial mammals	T	Deer
Small terrestrial mammals	T	Rat
Aquatic birds	F, M	Duck
Large terrestrial plants	T	Pine tree
Amphibians	F, T	Frog
Pelagic fish	F, M	Trout
Benthic fish	F, M	Flatfish
Small terrestrial plant	T	Grass
Seaweeds	M	Brown seaweed
Terrestrial insects	T	Bee
Crustacean	F, M	Crab
Terrestrial annelids	T	Earthworm



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[1]T, terrestrial; F, freshwater; M, marine

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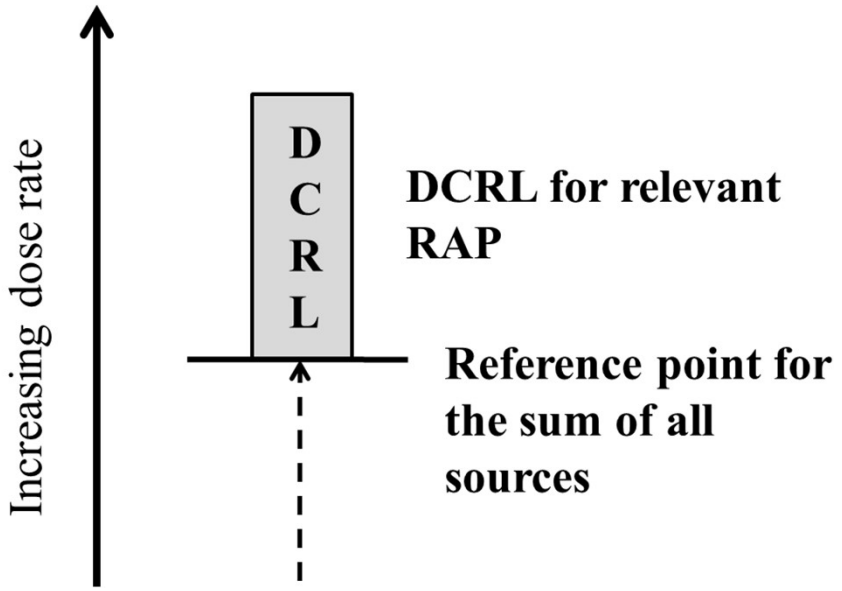
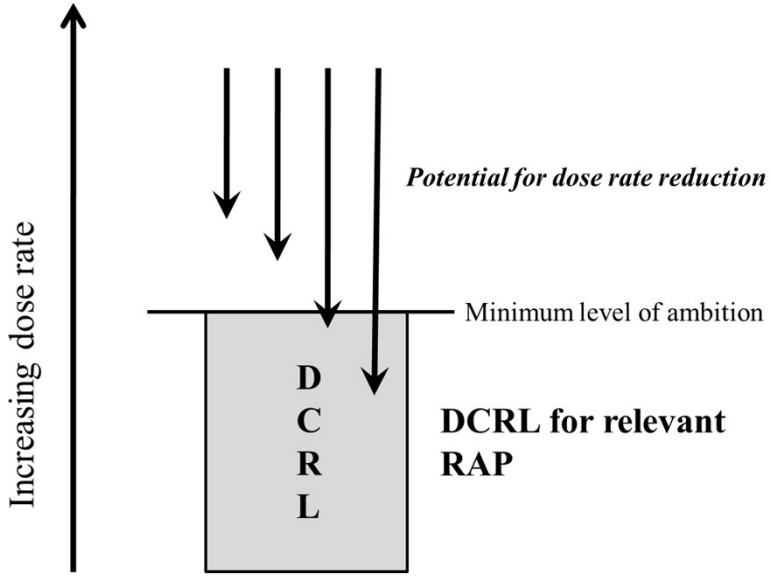
Derived Consideration Reference Levels (DCRLs)

ICRP Publication 108:

*"A DCRL can therefore be considered as a **band of dose rate** within which there is **likely to be some chance of deleterious effects** of ionising radiation occurring to **individuals** of that type of Reference Animal or Plant, derived from a knowledge of defined expected biological effects for that type of organism that, when considered together with other relevant information, can be used as a point of reference to optimise the level of effort expended on environmental protection, dependent upon the overall management objectives and the exposure situation."*

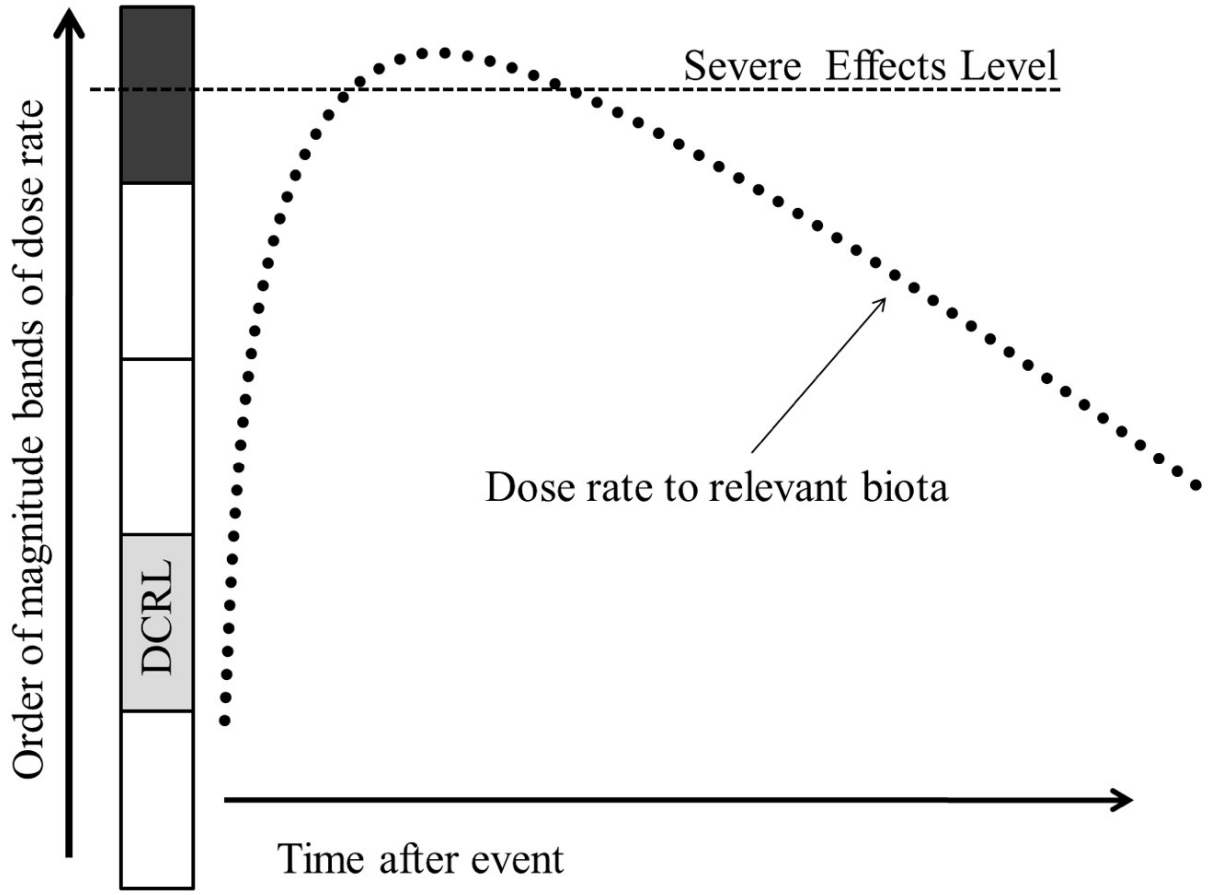
Application –
Planned and Existing Exposure Situations





[ICRP Publication 124]

Application – Emergency Exposure Situations



[ICRP Publication 124]

So what are (some of) the challenges?

The challenge of field results…

Are the DCRLs in the right place?

Do RAPs represent wider wildlife groups?

Evidence of ‘subtle’ effects of radiation exposure

Combined effects of radiation and other stressors

Field studies – the issues…

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.

Professor Tim Mousseau from the University of South Carolina, US, and

Related stories

Mammals decline in Chernobyl zone

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

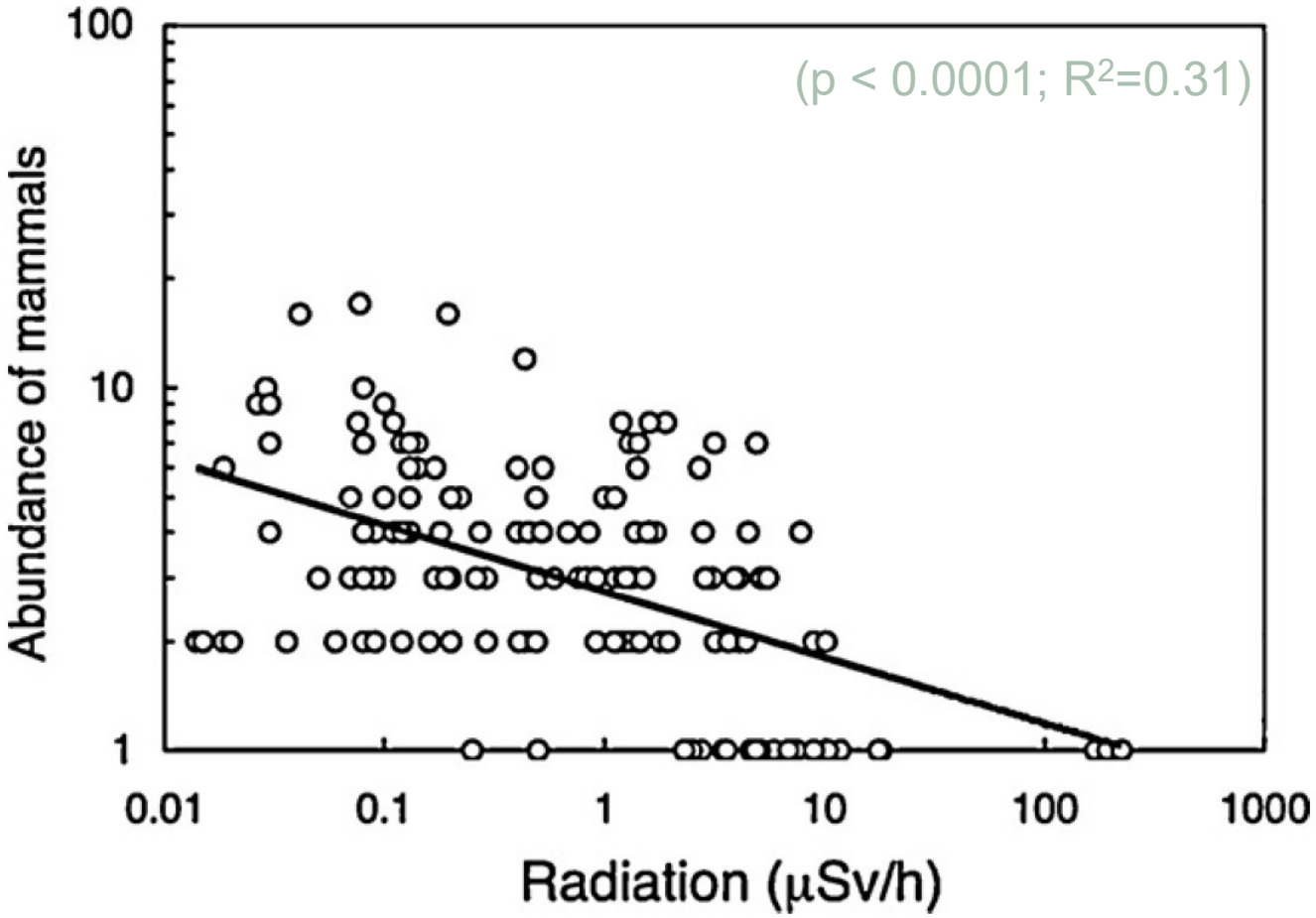
It contains some of the most contaminated land in the world, yet it has become a haven for wildlife - a nature reserve in all but name.

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

Mammals

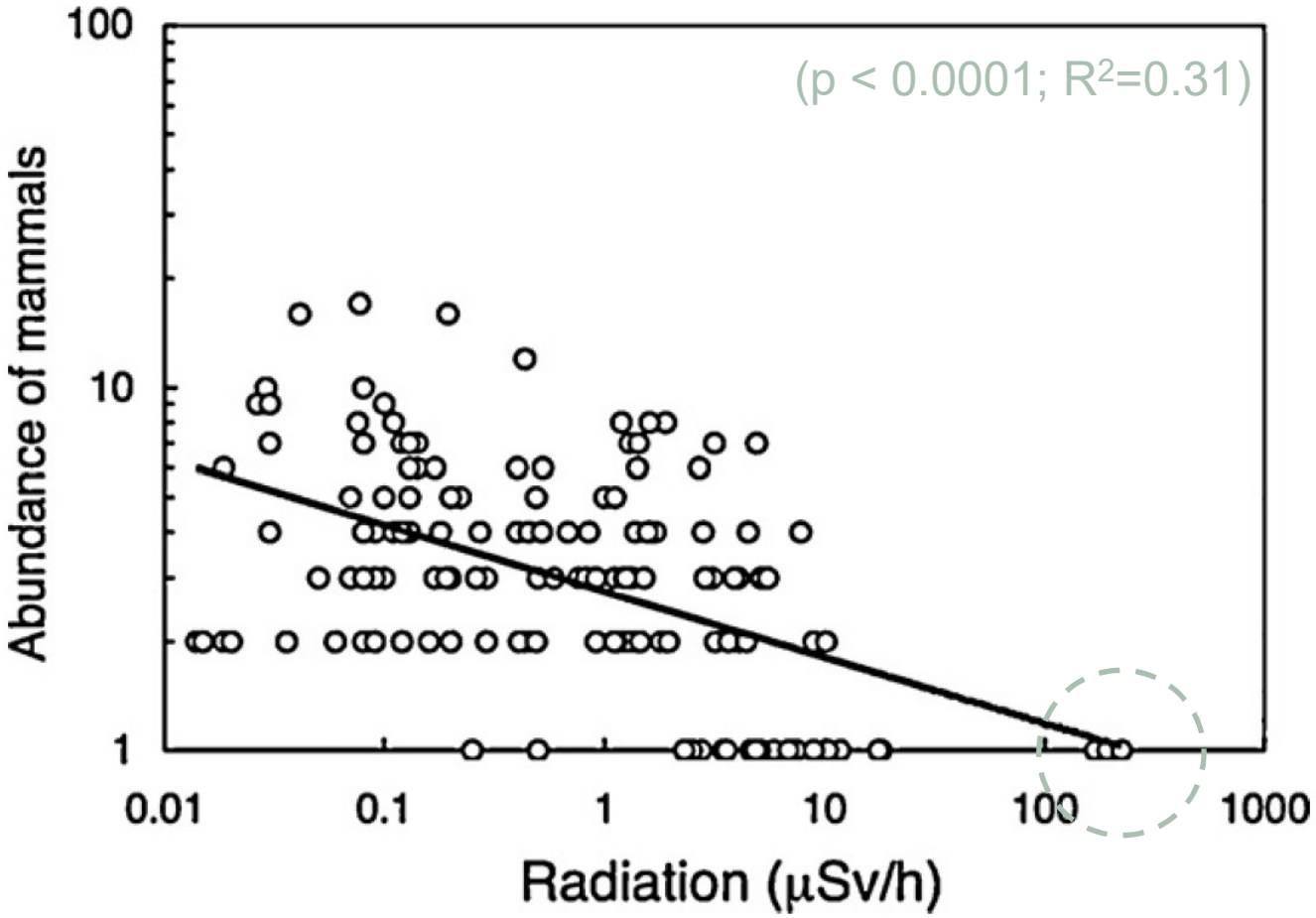


12 species

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

Moller & Mousseau 2013

Mammals

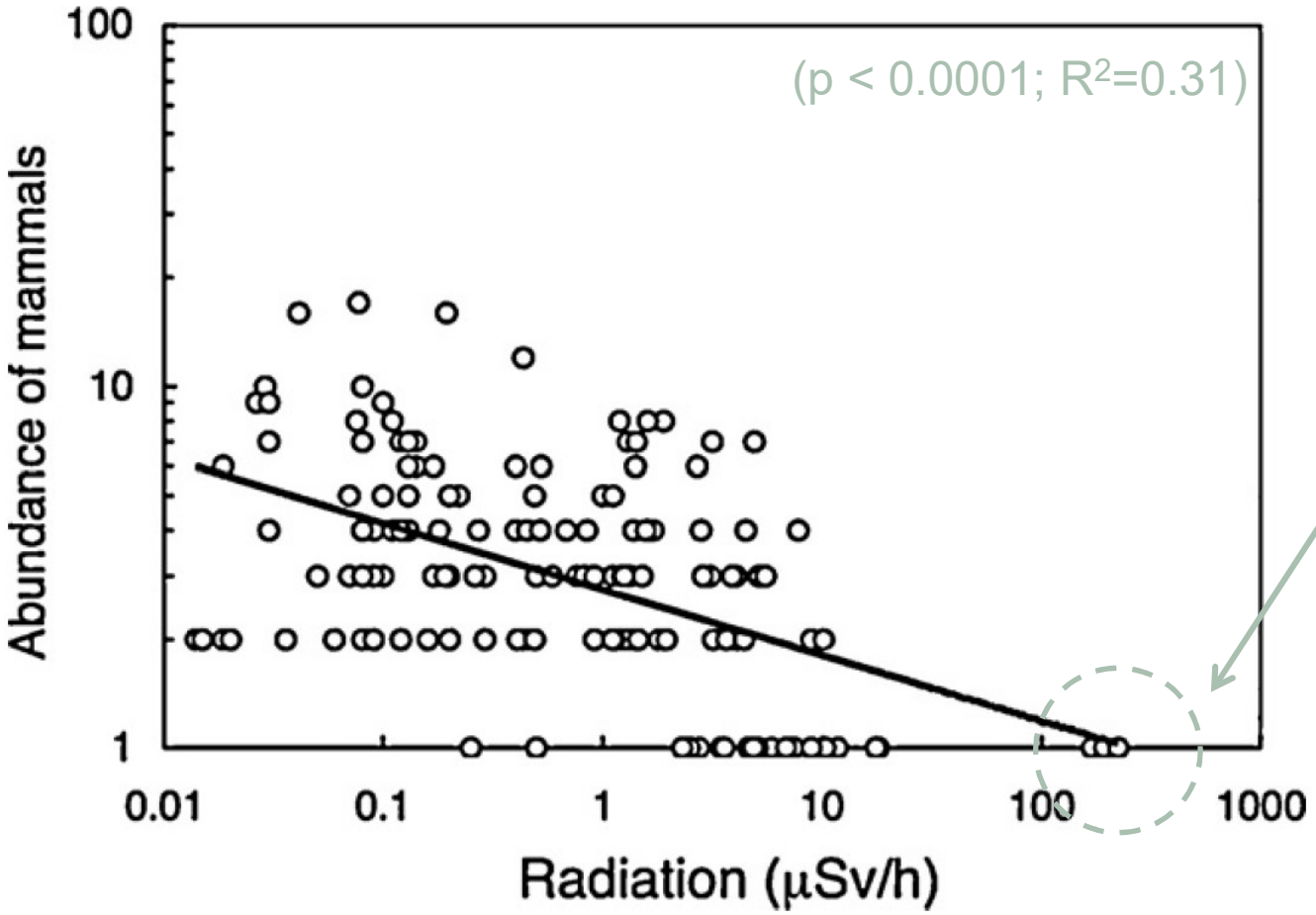


12 species

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

Moller & Mousseau 2013

Mammals



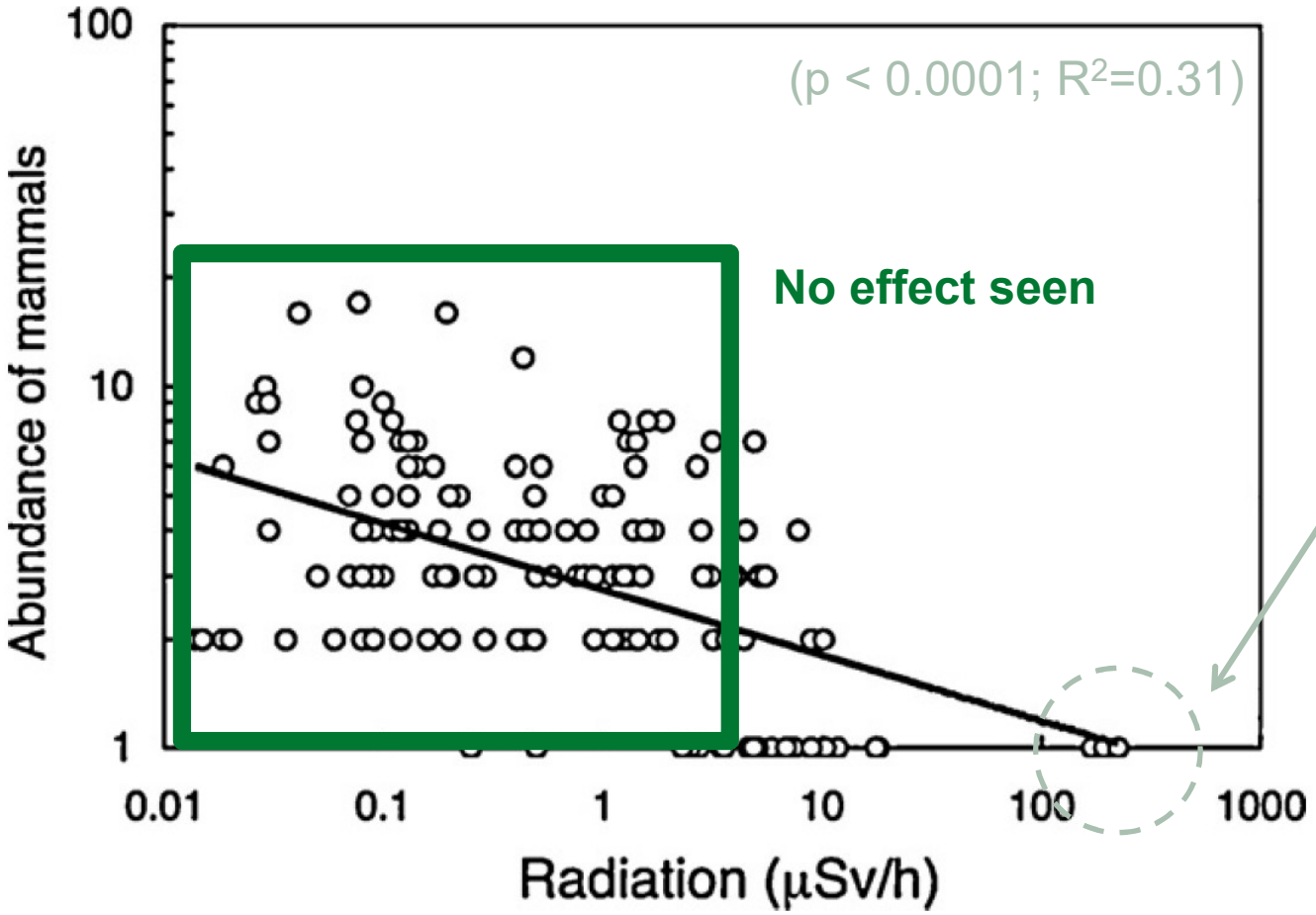
12 species

Red Forest?

Moller & Mousseau 2013

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

Mammals

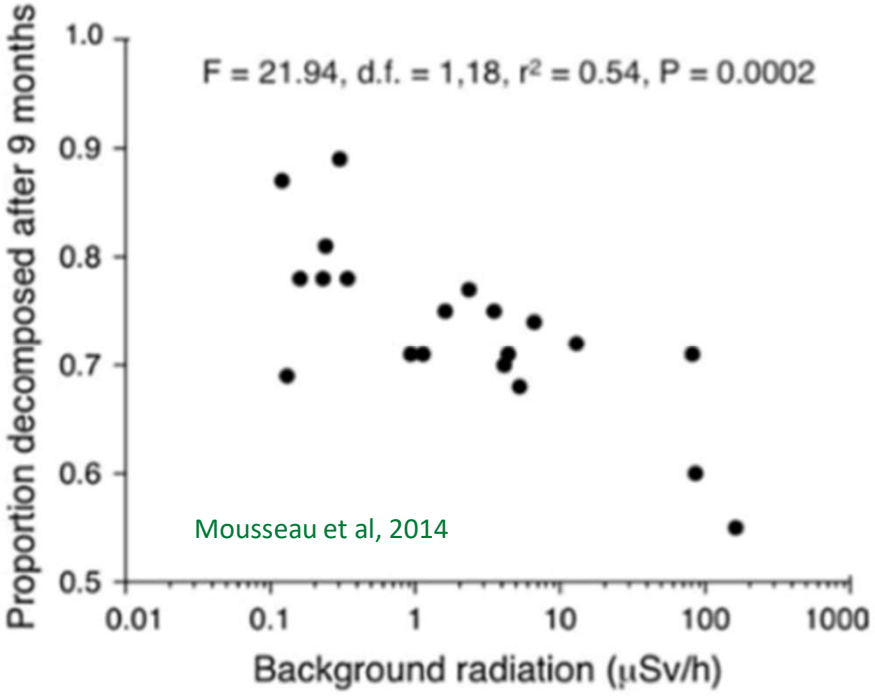


12 species

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

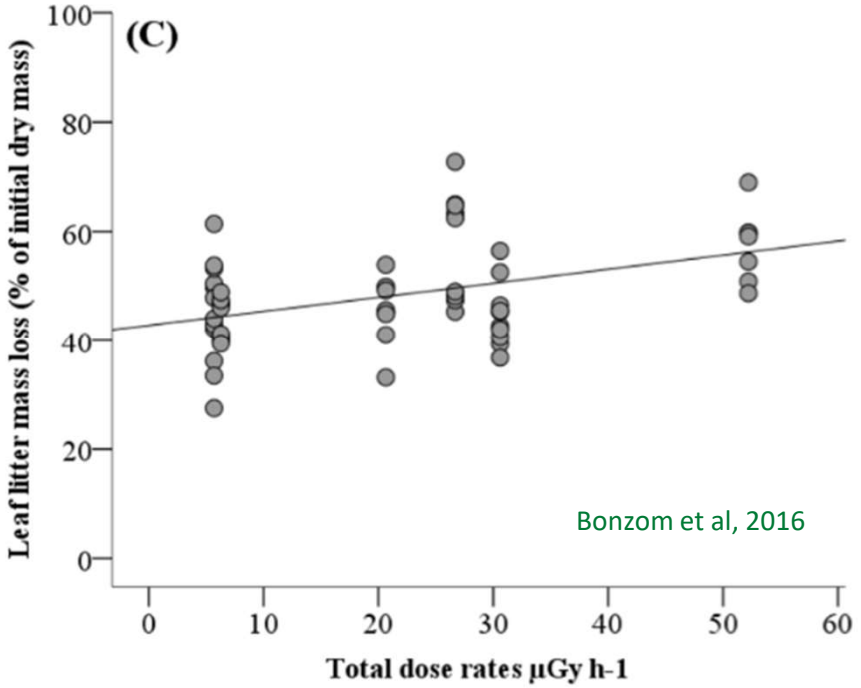
Moller & Mousseau 2013

Soil function – leaf litter decomposition rates



Mousseau et al, 2014

0.2 cm and <0.5 mm mesh
0.75 year



Bonzom et al, 2016

1 cm mesh
0.44 year

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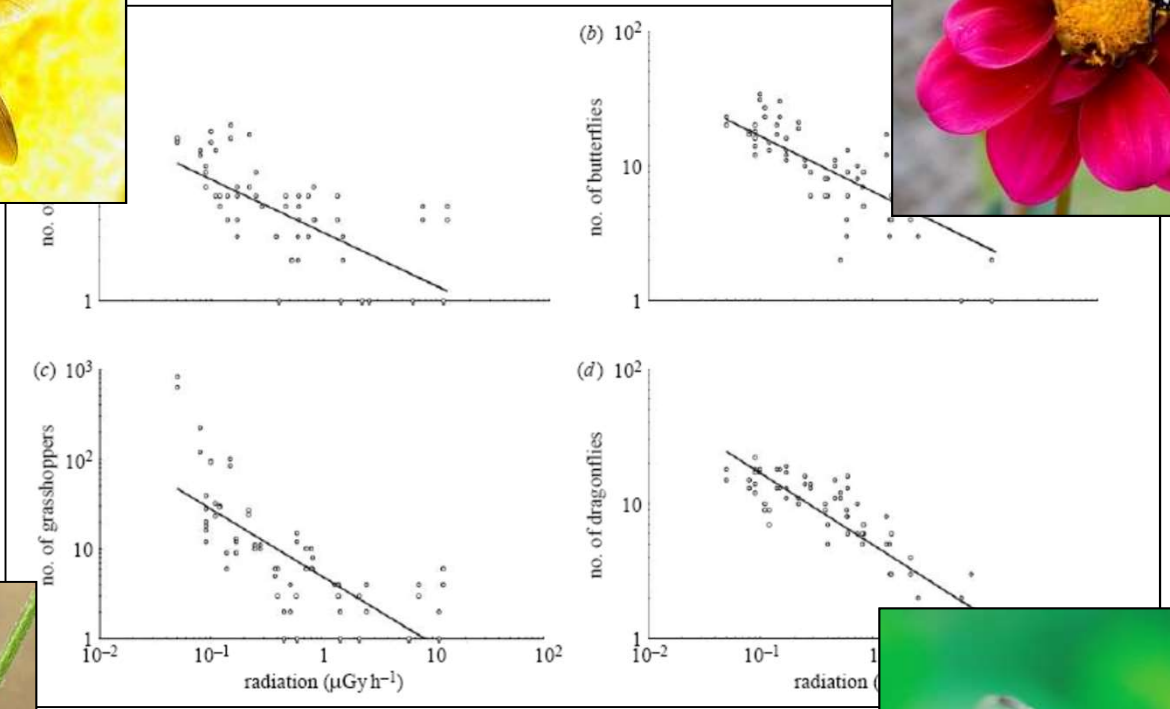
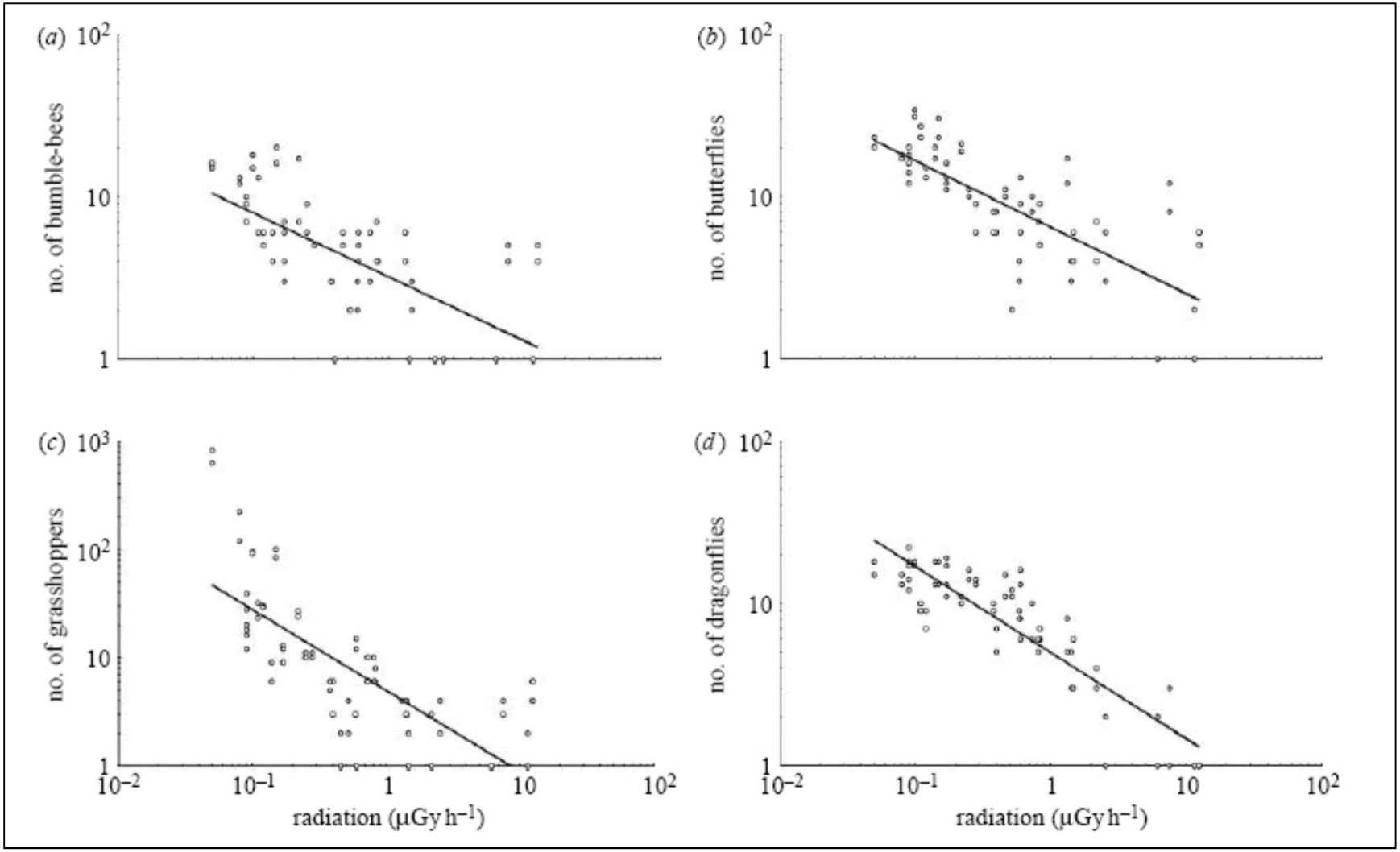
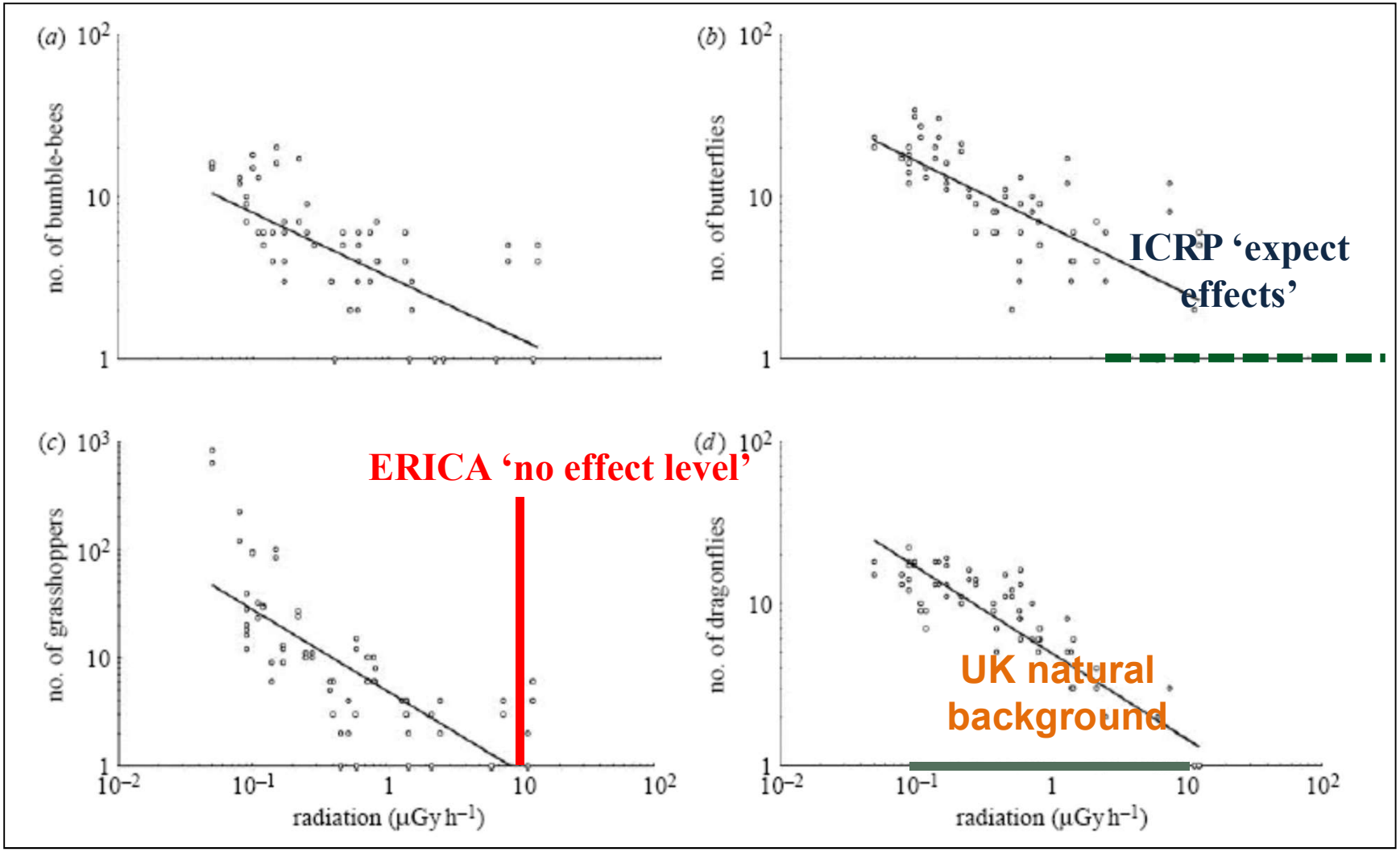
Invertebrates



Møller & Mousseau 2009 *Biol. Lett.*


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


(a) 10²
no. of bumble-bees
10
1
(b) 10²
no. of butterflies
10
1
ICRP 'expect effects'
(c) 10³
no. of grasshoppers
10²
10
1
ERICA 'no effect level'
10⁻²
10⁻¹
1
10
10²
radiation (μGy h⁻¹)
(d) 10²
no. of dragonflies
10
1
UK natural background
10⁻²
10⁻¹
1
10
10²
radiation (μGy h⁻¹)

Well isn’t it just that the DCRLs are in the wrong place then?

More data needed for radiological protection

Reference Animals and Plants

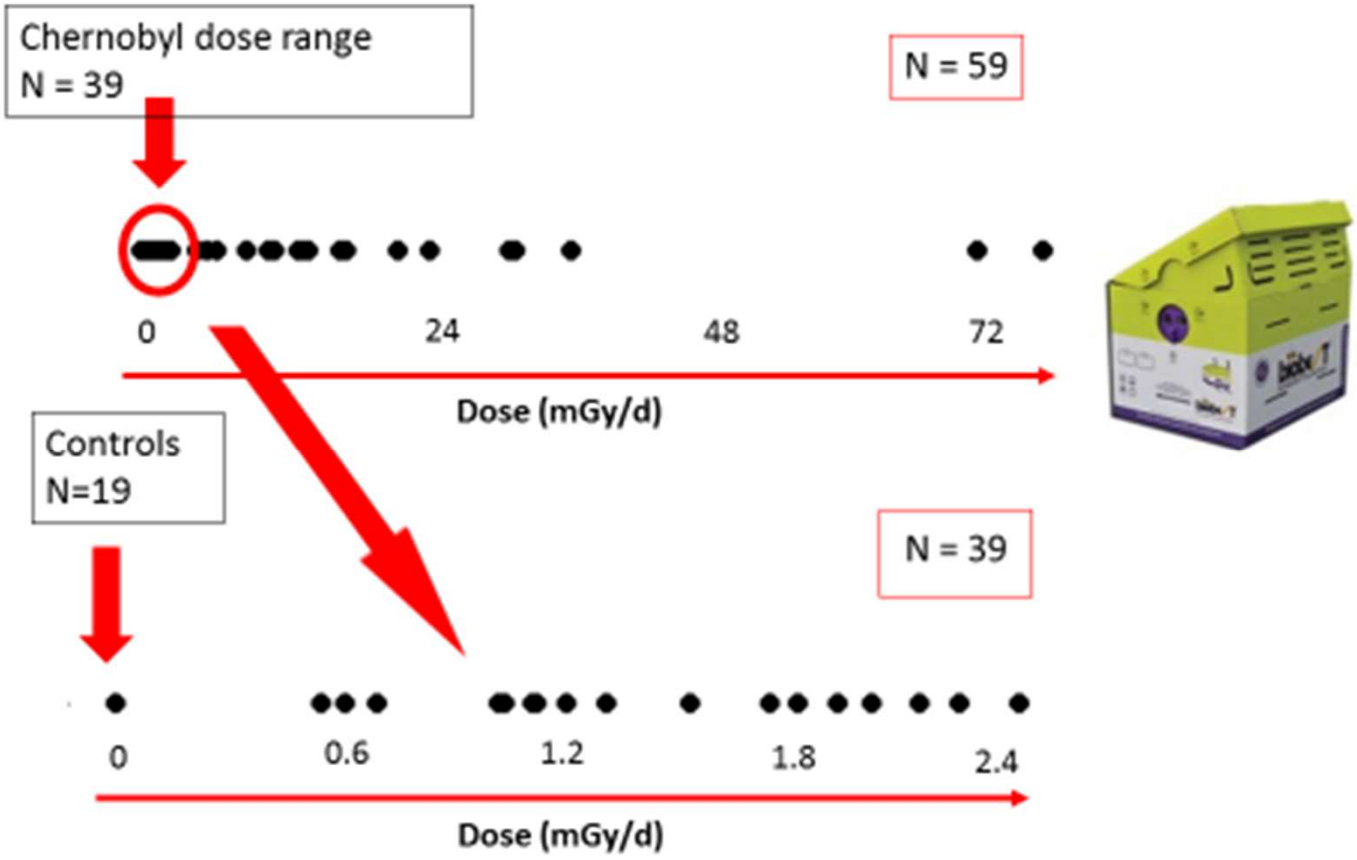
Hypothetical entity with assumed biological characteristics to relate exposure to dose and dose to effects

Dose rate $mGyd^{-1}$	Reference bee	
>1000	Mortality in adults (20Gy -3000Gy) Larvae (1 -2Gy)	
100-1000	Possible reduced reproductive success	
10 – 100	**Current DCRL** No information	
1- 10	No information	Chernobyl
0.1- 1	No information	
0.01 -0.1	No information	
<0.01	Natural background	

TREE

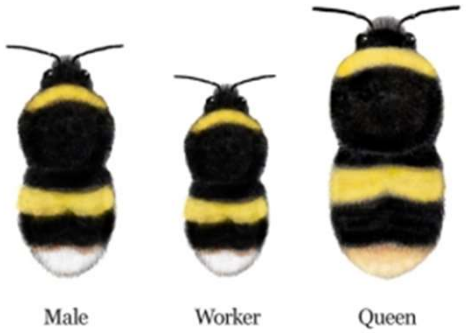
ICRP Publication 108

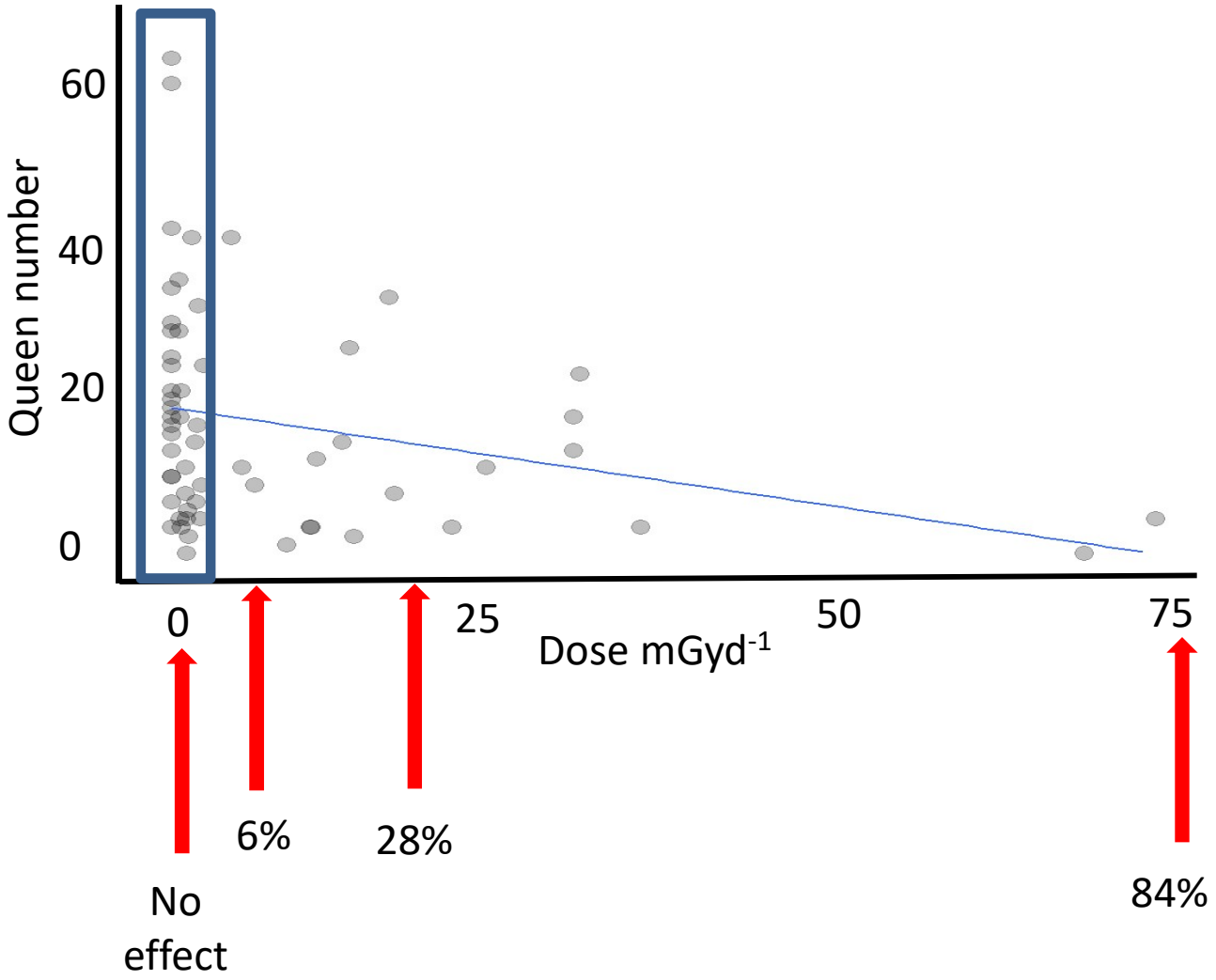
How does radiation impact reproduction (in the laboratory)?



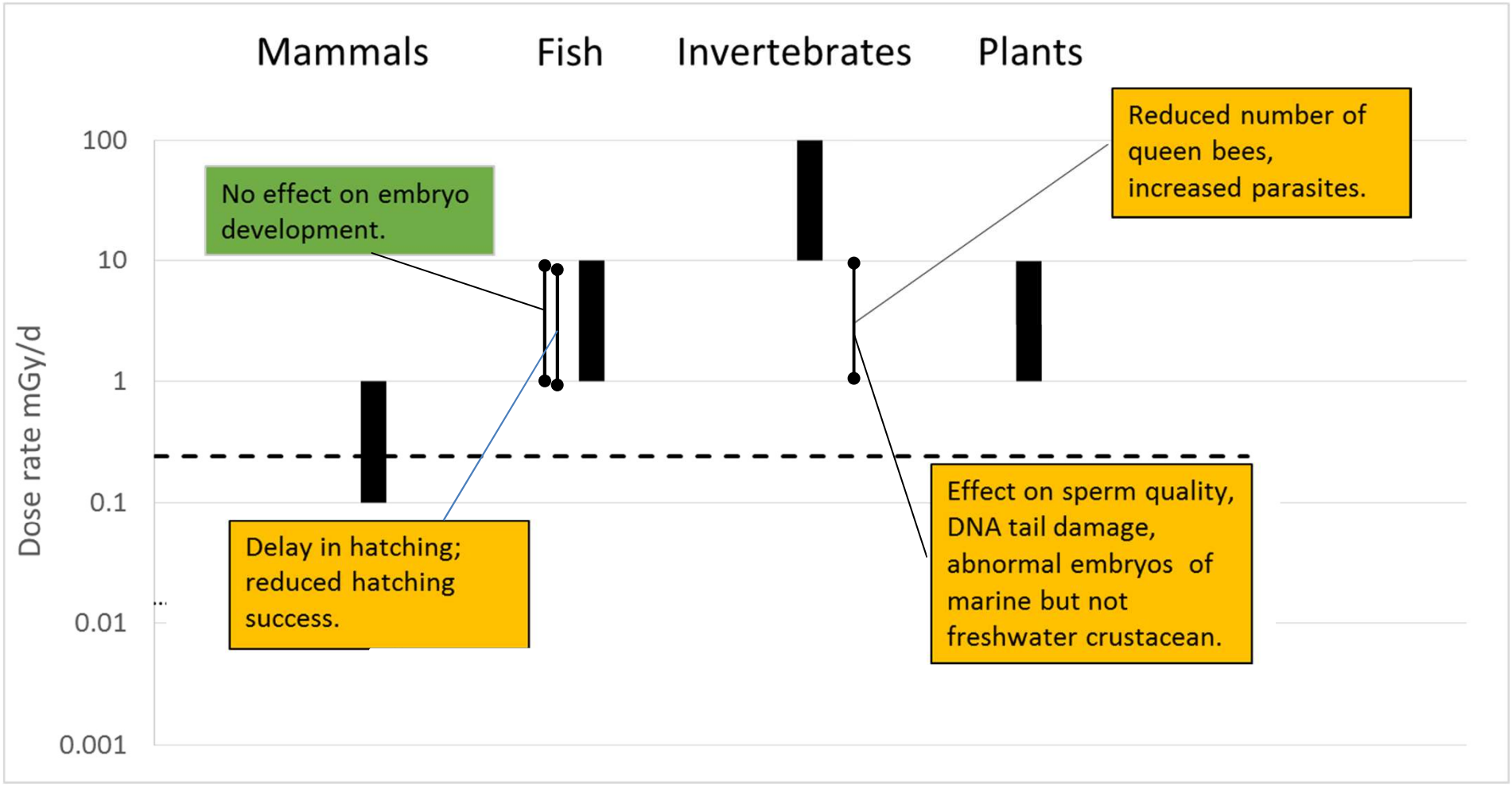
Reduced queen number (in the laboratory)

- Colonies can produce either males or new queens
- Queens are the biggest investment for colonies

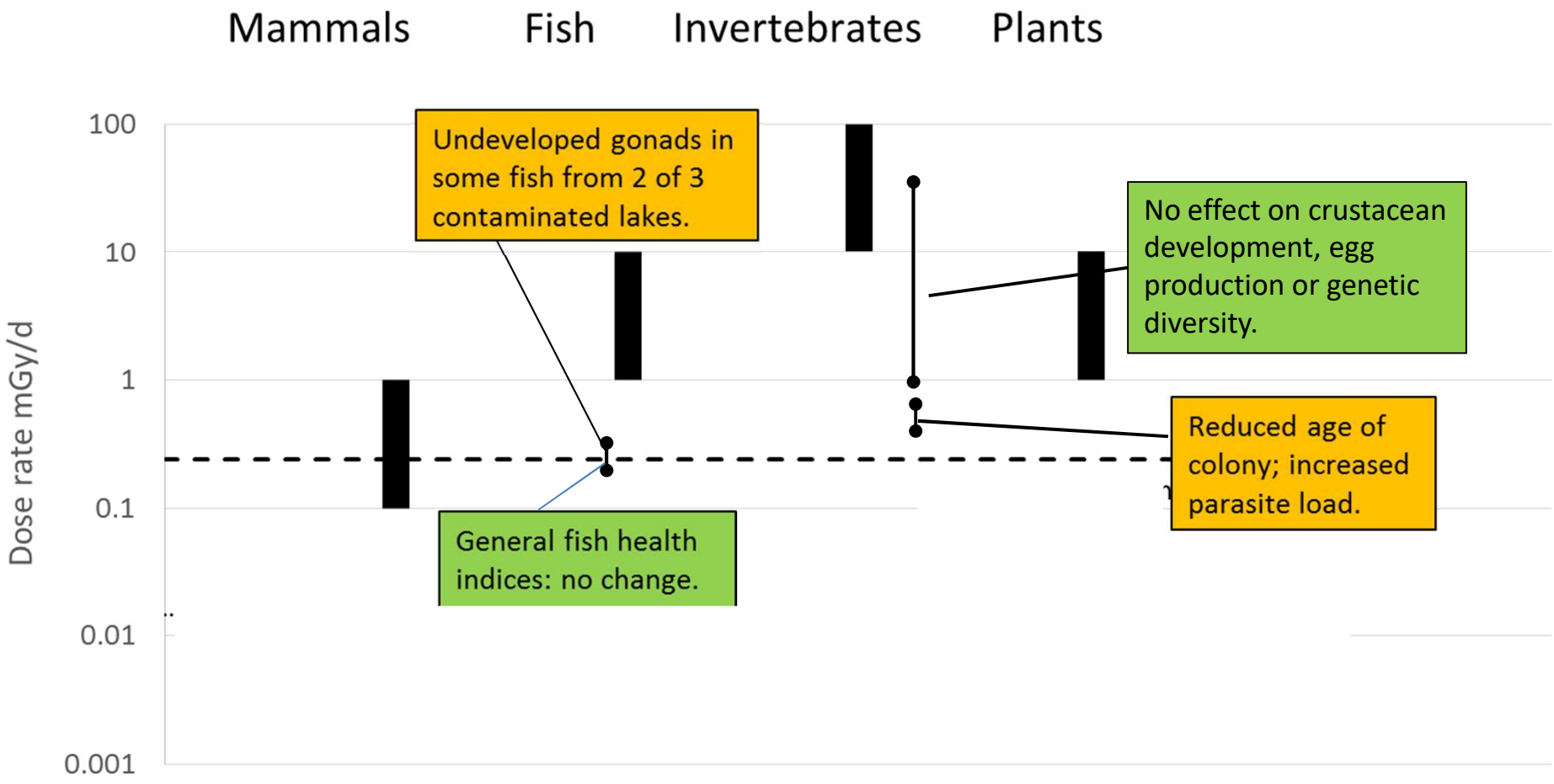




Laboratory studies

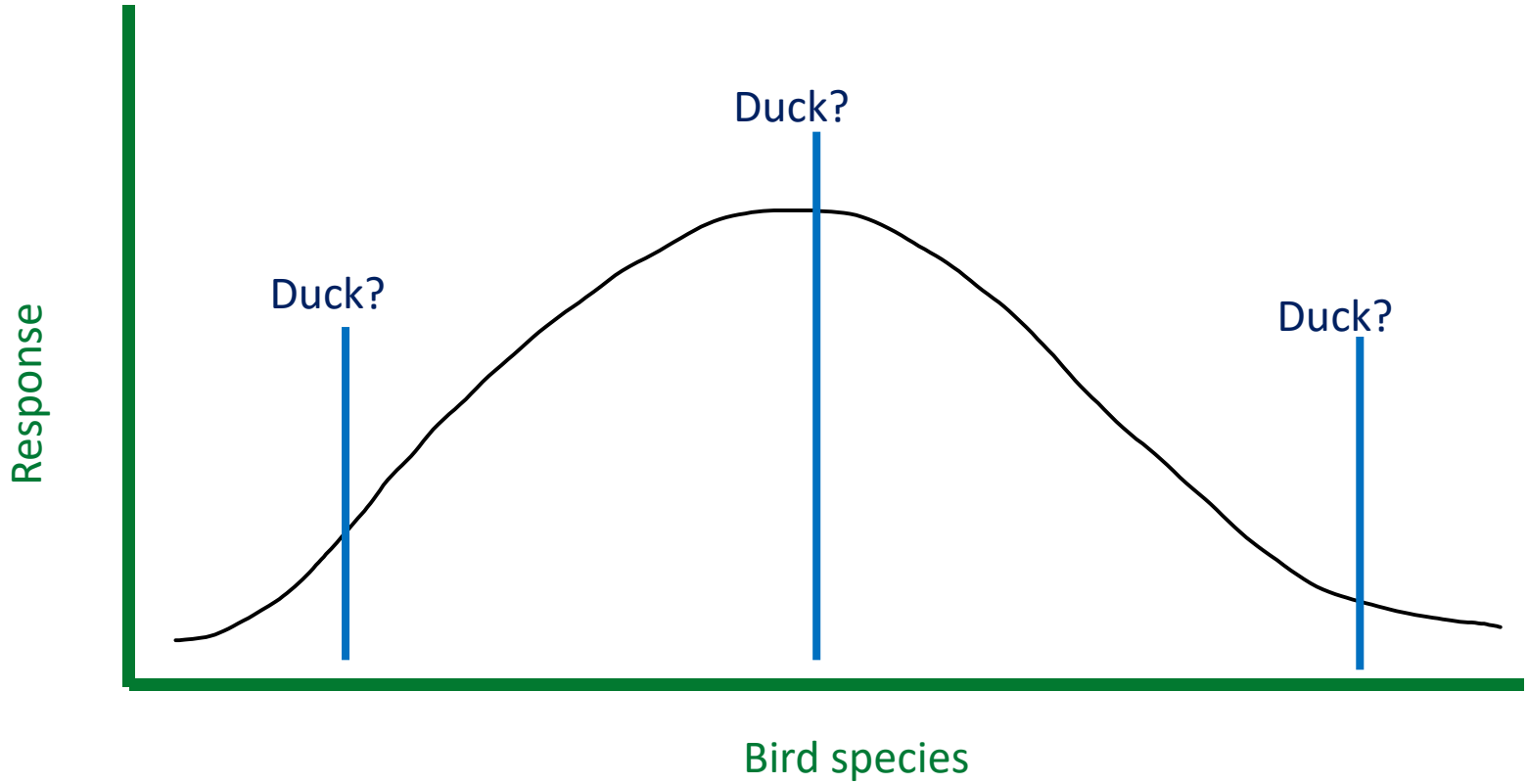


Field Studies at Chernobyl



TREE

Do RAPs represent wider wildlife groups?



Subtle effects of radiation exposure?

Historical exposure to radiation has not impacted on fitness in the laboratory

So what does all this mean?

Scientific questions to address

What are the key factors determining interspecies vulnerability to radiation?

Such fundamental mechanistic understanding is needed to define benchmark doses that are protective of a wide range of species; recent research (presented) suggest that current international protection benchmarks would not be protective of all organism groups

Scientific questions to address

What are the combined ecological effects of changes in developmental/reproductive endpoints of different species within an ecosystem?

A number of studies demonstrate shifts in developmental and reproductive endpoints (e.g. in flowering time, or sexual maturity) due to radiation exposure. Although these shifts in endpoints may be minor when considered in isolation, their combined ecological effects could be significant (e.g., delayed production of pollinators and earlier flowering may mean no floral resources are available for the pollinators)

Scientific questions to address

What are the interactions between radiation and other stressors (both natural and anthropogenic)?

Radioactivity rarely occurs in isolation from other contaminants and we have little knowledge of their combined effects

In summary

- Increased need to **demonstrate** that plants and animals are protected from radiation
- Need **knowledge** on effects of radiation to regulate effectively (nuclear power, medical uses etc.)
- Stakeholders are **challenging** regulators with (field) reported low dose rate effects
- Need to ensure system of radiological protection (for the environment) is **fit for purpose, robust and fully integrated*****