

Challenges and Controversies of Protecting the Environment from Radiation

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Radiation is unique as an environmental contaminant.

It is unlike all other pollutants on Planet Earth for two reasons...



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No other contaminant has been managed from such a strong

anthropocentric perspective

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The long-standing paradigm for protecting plants and animals from radiation

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ICRP 1977

If <u>man</u> is adequately protected, then so is the environment. Explicit radiological limits are <u>not needed</u> for the biota. If dose limits are set to protect humans, then the environment is automatically protected as well.



Organisms vary in their sensitivity to radiation

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ICRP and the Environment

ICRP 60, 1991

"The Commission concerns itself with mankind's environment <u>only with regard to the transfer of</u> <u>radionuclides through the environment</u>, since this directly affects the radiological protection of man."



²⁰ ICRP formed Committee-5 to develop an environmental protection system

An Jahar Sida

ICRP Committee 5

ICRP founded in 1928, Committee-5 formed over 75 years later

ICRP Publication 108



Reference Animals and Plants (RAPs); **Derived Consideration** Reference Levels (DCRLs); ...relate radiation effects to doses above natural background

RAPs and DCRLs

 $^{\sim}4-40;~40-400;~400-4000~\mu$ Gy/h

Wildlife group	Ecosystem ¹	RAP	DCRL, mGy d ⁻¹ (shaded)		
		\frown	0.1-1	1-10	10-100
Large terrestrial mammals	Т	Deer			
Small terrestrial mammals	Т	Rat			
Aquatic birds	F, M	Duck			
Large terrestrial plants	т	Pine tree			
Amphibians	F, T	Frog			
Pelagic fish	F, M	Trout			
Benthic fish	F, M	Flatfish			
Small terrestrial plant	т	Grass			
Seaweeds	М	Brown seaweed			
Terrestrial insects	Т	Bee	/		
Crustacean	F, M	Crab			
Terrestrial annelids	Т	Earthworm			
¹ T, terrestrial; F, freshwater; N	<i>I</i> , marine				
				[Publics	ation 108



Endpoints used by ICRP to estimate radiation effects to non-human biota

Early Mortality premature death of organism

Morbidity reduced physical well being, effects on growth and behavior

Challenge is how to use the se in a risk assessment **Reproductive Success** decreased fertility and fecundity



HInton, IER, Fukushima University

Chromosome Damage



One of the difficulties is that we manage wildlife at the level of populations, rather than individuals.

Therefore, any effect endpoint that we measure should correlate to population-level damages.

Fundamental Differences In Human and Ecological Risk Analyses

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What alters Population Growth Rate?

- marine and the destance

(Forbes & Calow, 1999)

41 studies that included 28 species and 44 toxicants

Mortality of juveniles

No correlation

Mortality of adults

Reduction in number of offspring

Time to reach sexual maturity



52%





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Extrapolating effects from the molecular level to the cellular level,....

...or from individuals to groups of many individuals and species, ...

Calow & Forbes, 2003

...is a major objective in ecotoxicology that has yet to be achieved. Chromosome Damage

The use of biomarkers (such as chromosome aberrations) in ecological risk analyses requires a link between molecular level effects and effects observed in individuals and populations **Ecosystems**

Communities

Populations

Individuals

Tissues

Cells

Molecules

Environmental Radiation Knowledge Base

- We have good knowledge about the effects of acute exposures to high levels of radiation
 - We know far less about the effects of <u>chronic</u> <u>exposures to low levels of</u> <u>radiation</u>



Most research is not directly relevant to responses in nature

Company and the State

Data Plentiful

Individual response Mortality Acute exposures External gamma Laboratory data Individual exposures

Least Relevant

Data Scarce

Population response Reproduction Chronic exposures Internal contamination Field data Multiple generations

Most Relevant

(Whicker and Schultz 1982)



Second Reason

When high levels of radiation cause humans to abandon an area (as occurred at Chernobyl and Fukushima), populations of wildlife appear to flourish

Indirect Effects of Human Abandonment



Abandoned towns of Chernobyl 340,000 people

Abandoned towns of Fukushima 100,000 people



With the removal of humans, wildlife around Chernobyl are flourishing

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48 endangered species listed in the international Red Book of protected animals and plants are now found within the Chernobyl Exclusion Zone



Increase of fish biomass off Fukushima after the accident because of the limited bottom-trawl fishing operations

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Fishing logbook analysis Off Fukushima, 150–200 m depth CPUE(kg/h) ratio before and after the accident (2012 vs 2007 - 2009)

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Toshihiro Wada, IER

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February 2012, off Iwaki



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Ratio of catch per unit effort (CPUE

the accident

before and after

Long-term census data reveal abundant wildlife populations at Chernobyl

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T.G. Deryabina¹, S.V. Kuchmel¹, L.L. Nagorskaya², T.G. Hinton³, J.C. Beasley⁴, A. Lerebours⁵, and J.T. Smith^{5,*}

Current Biology 25, R811–R826, October 5, 2015

Wildlife density in four uncontaminated National parks in Belarus compared to Deryabina et al. 2015. Long-term census data reveal abundant wildlife populations at Chernobyl *Current Biology*



Г. HInton, IER, Fukushima University

PSRER

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Polessye State Radioecological Reserve, Belarus

Large mammal populations 1 – 10 years, post Chernobyl accident



Comparison with other reserves

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Deryabina et al. 2015

Deryabina et al. demonstrate that, regardless of potential radiation effects on individual animals, the Chernobyl exclusion zone supports abundant mammal populations after 30 years of chronic radiation exposures





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RESEARCH COMMUNICATIONS RESEARCH COMMUNICATIONS

Where the wild things are: influence of radiation on the distribution of four mammalian species within the Chernobyl Exclusion Zone

Sarah C Webster^{1,2*}, Michael E Byrne^{1,2†}, Stacey L Lance¹, Cara N Love^{1,3}, Thomas G Hinton⁴, Dmitry Shamovich⁵, and James C Beasley^{1,2}



94 stations with remote cameras



Radiation levels had no discernible impact on the present distribution of boar, wolves, raccoon dogs or red fox within the CEZ.

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Instead, other habitat-related and human factors influence the distribution of mid-sized mammals in the CEZ.

These results are counter to those of Muller and Mousseau.



The irony about radiation as an environmental contaminant...

when levels of radiation cause humans to evacuate populations of wildlife appear to increase

increases are not because of any beneficial aspect of radiation (we know that radiation is harmful to individual plants and animals)

instead, the increase in wildlife numbers is due to the removal of humans and the environmental stress associated with our presence (e.g., cars, industries, farming)



The server and the designed

Wormwood Forest: A Natural History of Chernobyl Mary Mycio 2005





After spotting at least a half dozen black storks, I pleaded to stop the car for a closer look. But the guide laughed and said: "This is nothing. There are many, many more of them up ahead."

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It was true. Gray herons, mute swans that took off at our arrival like commercial aircraft, and thousands of ducks that rose into the air in a tornado-like cloud shared the flooded peat lands with dozens and dozens and dozens of great white egrets. There were so many egrets that I could only begin to count them before our appearance made them take off deeper in to the wetlands.

"All of the reflooded peat lands have become bird sanctuaries just like this one" said the guide. "If you come here in the morning or evening the birds make such a racket you wouldn't be able to hear me talk."

"It's so beautiful", I said, gazing through the binoculars. "If only it wasn't radioactive".

To which the guide responded: "If it wasn't radioactive, it would be a farm, and there would be no egrets"



When humans are removed, nature flourishes, even in the aftermath of the world's worst nuclear accidents...

the prover to de agrications

Revitalization for Humans

Removing contaminated topsoil, cutting down contaminated trees, and conducting other remediation methods that result in humans <u>returning</u> to evacuated areas...

are all detrimental to wildlife populations.



Over 9,000,000 bags of radioactive waste from decontamination efforts, stored at 114,700 locations

Third lecture will summarize the findings of the IAEA Chernobyl Forum (2006) relative to environmental effects....and point out how the IAEA conclusions started a dichotomy in radioecology that still exists today.