

**Conclusions from
WORKSHOP ON UNCERTAINTIES IN FIELD STUDIES ON CHRONIC LOW LEVEL EFFECTS DUE TO
RADIATION (CEH Lancaster, 4th-6th February 2013)**

By bringing together scientists involved in environmental and/or laboratory studies of radiation effects, allied ecological fields and radiation protection specialists we aimed to:

- gain a greater understanding of the impacts of radiation on wildlife
- consider uncertainties in dose and dose rate estimation including measurements in the field
- discuss field based studies of effects of radiation at low chronic dose rates
- discuss current methods for deriving numerical dose and dose rate benchmarks for application in environmental assessments
- start to understand the basis behind some of the contrasting results and interpretations of the effects of radiation in the environment
- agree future research priorities and mechanisms whereby information can be shared.

Key questions related to uncertainties in field estimates identified during the meeting were:

- 1) How much is known about the influence of confounding factors such as other contaminants, weather, food or nutrient availability?
- 2) How reliable are and dose rate measurements in laboratory and field conditions in estimating external and internal dose and dose rate – how should internal and external and dose rate be measured in the field? How to improve radiometric measurements in the field (e.g. reducing ‘background’)
- 3) How to deal with spatial variability (e.g. in dose and dose rate due to contamination) and species mobility in the field
- 4) Do laboratory tests reliably represent the field situation?
- 5) Do biomarkers/endpoints relate to long-term population effects?
- 6) How much uncertainty is related to data selection in derivation of the Species Sensitivity Distribution (SSD) for radioactivity?
- 7) What is the real shape of dose-response curves, particularly at low dose and dose rates? Is hormesis real? Is hormesis important? What are the consequences of non-targeted mechanisms such as bystander effects and genomic stability?

The initial conclusions of the workshop are briefly outlined below:

There is a currently unexplained discrepancy between adopted benchmark screening values and some effects data from field studies. There is an urgent need to resolve these issues in part as regulators are being questioned regarding the data they use in their assessments – current benchmark dose and dose rates are perceived as not being low enough, despite being close to typical natural background dose rates (excluding that from inhalation of Rn and daughters).

- We need to work out how to address the situation and clarify what is contributing to the differences. Examples of possible actions included:
 - Gathering more field data with careful consideration of the structuring of sampling;
 - Making data freely available via data portals with **digital object identifiers** (i.e. doi numbers) assigned to datasets etc.;
 - Collaborating on data analysis;

- Improving estimation of external and internal doses and dose rates in the field;
- Independent testing / verification of key findings.

As first steps:

- We should try to estimate the best dose/dose rates we can for the available field data which may reduce some of the discrepancy
- There are a number of published comparisons of model predictions of transfer versus field measurements, and one for dose comparison at Chernobyl
- There are no independently replicated studies of effects at radiologically contaminated sites – the participants are well placed to address this deficiency
- Doses and dose rates need to be estimated for different life-stages (e.g. bird egg - adult bird, caterpillar - butterfly).

Problems with laboratory studies and whether they adequately represent field exposure and effects

- Is it possible that lab studies might underestimate hazard because of the choice of species, endpoints and the exposure duration – do we need more long term chronic exposures in lab experiments?
- Laboratory studies are usually conducted using an external gamma source only. This does not represent the mix of radionuclides and internal/external dose experienced in the field. How much does this matter?
- Laboratory experiments are generally conducted under optimal growth conditions (plenty of nutrients, absence of stressors) whereas in the field higher radiosensitivity may be linked with sub-optimal conditions
- Discrepancy in comparative radiosensitivities of different organisms – e.g. between EDR₁₀ values used in SSD, classic bar charts for acute radiosensitivity of organism groups, chronic exposure data and field measurements
- Consider the need for standard protocols to be set up for both field and lab experiments.
- Longer term trans-generational studies may better match the field situation - but how long is long? It will depend on the life-cycle and life-span of species.

Effects studies and the FREDERICA database

- Need to look at methodologies and application of data to field exposures
- Is it possible to predict effects in one species using data from another? Currently there are limited data on radiosensitivity between species
- Need to re-evaluate the usefulness of the [FREDERICA](#) data and work out what more we could use the data for. Repeatability/ reproducibility/ significance/reliability of data need to be assessed
- Supplement the FREDERICA database with more data that could be included in the SSD. Consider conducting a series of small simple experiments to get the basic information on effects within populations (within the [STAR network](#) work is being conducted using biomarkers (1-2 year tests) and OECD protocols)
- Can phylogenetic analyses of data be conducted to identify relative radiosensitivities by taxonomic groupings and extrapolate effects data to other species?
- Endpoints – perhaps only the reproductive organs or accumulating organs (e.g. liver) are important
- Consider screening values for populations – IRSN, SCK•CEN and SU are currently developing benchmarks/ screening values to protect populations
- Future work should be innovative – branch out and try something different – incorporate advances in radiobiology (such as bystander effects).

Dosimetry

- Need to try to determine doses in the field better – e.g. measuring whole body concentrations directly
- Perhaps we need to concentrate more on doses to organs in biota at least for those radionuclides that are known to act at specific organs (e.g. Sr and bones, I and thyroid) and whole body doses may be less relevant
- There are many current potential errors in dose measurements for both external and internal dose – intercalibration problems when measuring dose with different instruments needed.

Data gaps for transfer

- Quality and quantity of data on transfer of radionuclides to organisms is highly variable and data are often sparse if available at all
- CEH will be making data for radionuclide transfer to RAPs (in the UK) available online (<http://dx.doi.org/10.5285/e40b53d4-6699-4557-bd55-10d196ece9ea>) associated with the imminent submission of a paper – potentially useful for insect assessments at Chernobyl as there will be flying insect CR values which are largely lacking from existing databases.

Future recommendation - publish guidelines on how to conduct field experiments

- It was acknowledged that there is information already published on conducting e.g. biodiversity surveys – it was suggested that a briefing paper with key links would be useful
- Regulators attending were highly supportive of the need for a briefing paper arising from the workshop so work funded in the future could benefit and would therefore create more useful data
- The briefing paper could focus on issues specific to the Chernobyl and Fukushima field sites and cover aspects such as the estimation of dose, heterogeneity, pseudo-replication, the influence of covarying factors (e.g. toxic chemicals), data adequacy and unbiased selection of sampling sites. The manner in which the document will evolve and be disseminated needs to be decided
- Before commencing it would be important to determine whether similar papers have been prepared for e.g. chemical studies. - e.g. SETAC mesocosms
- Studies would need to :
 - Ensure they cover the range in dose rates and focus on the “most important” effects
 - Ensure there are adequate number of control data and/ or reference sites
 - Take place at suitable times – e.g. spring for vertebrate (e.g. mice) not late summer as often done, better to cover a whole year rather than spot measurements
 - Think like an ecologist and not a toxicologist – e.g. need to study a range of ages which would require sampling at various times during a life cycle.

Co-operation

- ICRP are putting together a list of PhD ideas to help fill gaps with RAPs (Reference Animals and Plants) although it is not publicly available yet. Group could expand that list and not just focus on RAPs
- Groups with expertise in dose estimation could assist those which have relevant radionuclide activity concentration data in estimating internal doses
- Need to increase awareness of freely available guidance for field studies
- STAR – has selected two observatory sites (Poland and Chernobyl) - Potential opportunities for collaborative research within new EC project (COMET) partially through the future open calls or via the [ALLIANCE](#)
- Data could be shared between studies via common databases, or via datasets published on-line with an associated doi
- There are many groups in Russia, Ukraine and Belarus doing work in the Urals, Semipalatinsk and CEZ that would be very willing to collaborate with workshop participants - this option needs to be explored.

Data

Open access to relevant data and databases from all sources would be valuable once it has been published. Some access to additional data is now given in supplementary tables. There is an EC Directive regarding making environmental data available (INSPIRE). Consequently, 'published' data sets (with doi's) and data papers are starting to appear. For recent examples giving detailed individual data for a variety of relevant measurements from CEH see <http://dx.doi.org/10.5285/2641515F-5B76-445C-A936-1DA51BF365AD> and <http://dx.doi.org/10.5285/1a91c7d1-ec44-4858-9af2-98d80f169bbd>.

- There is a benefit in collaborating with others regarding availability of data and joint participation in field studies. Clearly, new data needs to be published before making it freely available
- IRSN should re-evaluate their evaluation of field data (<http://www.ncbi.nlm.nih.gov/pubmed/22336569>) using available specific Chernobyl CR values rather than TRS values. CEH could provide some data from Chernobyl for birds and additional data for bees
- It would be helpful to compile published information on field studies, some of which may be in grey literature
 - Mousseau may be able to provide their material as they hope to translate their papers into Japanese and Russian (which would be completed if a small project is funded);
 - CEH will provide data from studies at Chernobyl online
- Consideration could be given to explore how far apart sites need to be independent?
 - the Møller and Mousseau dataset and possibly others could then be reanalysed with this in mind
 - Good statistics was considered to be vital – could start with the bird data
- Possible opportunities to take some of the issues forward in MODARIA – e.g. heterogeneous dose rates with respect to organisms (i.e. different organs) and the environment (i.e. spatial heterogeneity and how animals utilise their environments) are already being considered.

Comments on the workshop and future developments

- All agreed that this was a useful first meeting in starting to discuss and resolve discrepancy in environmental radioactivity studies. All present agreed that they would like to meet again¹ to address issues raised using a similar format of meeting
- In the future, perhaps workshops could focus on a particular topic although workshops such as the current one were a good opportunity to talk to people from different disciplines
- It would be best to keep the group small for effective communication and active involvement
- There needs to be an output at the end of the workshops e.g. paper, web-site dissemination
- Openness was very refreshing
- Consider inviting presentations from a statistician and ecologist
- Need to extend networking outside of usual contact groups.

The presentations from this meeting will go on [CEH PROTECT wiki site](#) which is currently linked to STAR web site.

Feedback will be given at the [IAEA MODARIA](#) workshops in May

¹ Tentatively planned under the STAR network for May 2014