**Development of population level biomarkers for low dose radiation: the importance of non-targeted effects.**

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Recent moves within ICRP to develop an integrated approach to radiation protection of both humans and non-human biota are focused on regulating dose to exposed populations based on behaviour, size, lifestyle and “radiosensitivity”. Currently man and 12 reference organisms are used covering various taxonomic groups, behaviours, and exposure scenarios - e.g. marine, terrestrial, sediment or airborne. However most biologists agree that particularly in low dose exposure legacy sites, the factors determining effects and outcomes are far more complex that this simple framework suggests. The issue is developing reliable predictors of system or ecosystem health rather than relying on biomarkers that give information about effects on individual cells, organs or organisms. Approaches to this include the Adverse Outcome Pathway (AOP) which looks at multiple levels of organisation from gene to ecosystem Another approach used by our group is to look at the role of non-targeted effects such as genomic instability (GI) and bystander effects (BE). These mechanisms involve transmission of information between different levels of organisation. In the case of BE signals from exposed to unexposed cells or organisms coordinate response at higher levels of organisation permitting population responses to radiation to be optimised. GI is more complex as it involves not only signalling but also trans-generational transmission of genetic or epigenetic changes and may lead to long-term adaptive evolution. GI may also be involved in memory or legacy effects, which contribute a further component to the dose effect measured in legacy sites. Our recent analysis of the contributions of memory and legacy effects to the total effect using data sets from Chernobyl and Fukushima (voles, birds and butterflies) suggest this type of analysis may help reduce uncertainties over lab to field extrapolations. Given the clear discrepancy between actual data measured in the field and dose effects generated using databases populated mainly with acute lab based experimental data, it is imperative that we strive to develop meaningful holistic systems for protection of those living in contaminated ecosystems.