Response to reviewers "Towards an ecological modelling approach for assessing ionising radiation impact on wildlife populations", Article reference: JRP-102622

We have addressed all the comments and we think that, as a consequence, the presentation of the mathematical models as set out in Section 3 is now sufficiently improved. In particular, the basis for the Chernobyl Red Forest model is more clearly set out and all the quantities used in the model equations are now correctly defined. In doing this we had to be careful because the Red Forest model was described in our previous paper, so it was important not to add too much information that could duplicate what was given in that paper. We trust our efforts will be found to be acceptable.

Comment	**Response**
Page 1, Line 30: 'to a new sensitivity'	Done
Page 1, Line 48: 'approaches with Member States' (note capitals)	Done
Page 2, Line 24: 'The IAEA draws on'	Done
Page 2, Line 27: 'lower bounds of…as criteria to use in excluding dose rates from further consideration but leaving the regulator free to decide what doses rates from within the band are acceptable.'	Done
Page 2, Line 31: 'In 2004, the IAEA'	Done
Page 2, Line 49:'impact of ionising radiation on populations'	Done
Page 3, Line 22: 'spanning the MODARIA'	Done
Page 3, Line 34: 'difficulties in understanding'	Done
Page 3, Line 37: 'difficulty in interpreting'	Done
Page 3, Line 42: 'induced by such low-level exposures on populations'	Done
Page 3, Line 43: 'study different from short-term'	Done
Page 3, Line 50: 'however the applicability of hormetic'	Done
Page 4, Line 17: 'issues in the interpretation'	Done
Page 4, Line 28: Although the term 'non-targeted effect' is widely used, it would be helpful to explain it here, otherwise the reader will not appreciate why this is associated with a saturated response with no increase in effect with increasing dose.	Done. Explained that a non-targeted effect is an effect that is not the direct consequence of radiation interacting with the DNA of a given cell but may be imported from neighbouring irradiated cells.
Page 4, Line 47: 'dose/exposures' could be reduced to 'exposures'	Done
Page 5, Line 10: 'damage and recovery'	Done
Page 5, Line 20: 'of a 'population''	Done
Page 5, Line 21: Delete 'hereby'	Done
Page 5, Line 27: 'doe rate' would be better than 'dose level' also 'dose rate in the presence'	Done

Page 5, Line 39: I did not understand the need for the word 'continuous' in this context. Age is a continuous variable, but age classes are not continuous, and it is these that are mapped to compartments. There are studies in which the compartmental approach is extended to an infinite number of infinitesimal compartments. Such an approach can legitimately be described as continuous.	We merely wanted to emphasise the difference with matrix models where time and the number of individuals of the population are discretised. We accept this was unclear so we changed the sentence to: "In the ODE population model, time and population are continuous variables and the age classes are mapped to compartments governed by differential equations".
Page 6, Line 33: 'in the MODARIA studies.'	Done
Page 6, Lines 35 to 43: The phrase 'mortality, morbidity and reproduction' is used twice in this paragraph. I was left uncertain whether this was being used in two different ways, i.e. in relation to measurements on individuals under controlled conditions and in relation to total, mixed populations in field conditions. In any event, this might be a distinction worth mentioning here.	We see that we introduced a confusion which is hopefully corrected by rewriting the paragraph as follows: *The primary sources of radiation effects parameters for wildlife are the FREDERICA database … In these sources, data are given for three relevant endpoints: mortality, morbidity and reproduction. Therefore, we identified the need to use these key endpoints in population modelling aiming at assessing protection levels for populations. These sources also allowed the identification of the relevant species (and endpoints) that …*
Page 6, Line 49: 'similar issues to those in'	Done
Page 6, Line 51: 'chemical risk assessment'	Done
Page 6, Line 54: 'The endpoints of the models are similar to those of the population'	Done
Page 6, Line 56: 'damage and'	Done
Page 7, Line 4: 'distributions for'	Done
Page 7, Line 51: 'effects on a'	Done
Page 8, Lines 11 to 31: In these equations, various coefficients (e.g. d, η, α, ε, κ, DR) are not defined. Z is introduced as the number of dead individuals, but plays no part in the equations, L = X+Y+ suggests that a term has been omitted, presumably W, because this then gives the total number of living individuals to compare with the carrying capacity. Although it involves some repetition with a previously published paper, I think that the model equations should be given and explained in full. This will help the reader appreciate how the combined radiation plus chemicals model derives from this model by collapse to a single domain and extension to two types of stressor.	Indeed the term W was accidentally omitted (now corrected). Z is superfluous and is eliminated as suggested. The equation's coefficients are now explained. T_i is now re-labelled as L_i as they mean the same thing. All the model parameters are now defined in a new paragraph introduced for this purpose. In addition, we have now given equations for the terms M_i , M_{iF} and M_{iR} representing spatial displacement fluxes for population, fecundity and recovery pools, respectively. With these additions, the model equations are now given in full and all the parameters are now defined, just as the reviewer requested. Further details are in our previous article, duly cited, and should not be given to avoid duplication with that paper.
Page 8, Line 44: 'For this reason, in the present'	Done
Page 8, Line 48: 'propose a new set'	Done

Page 8, Line 49: 'as a basis the'	Done
Page 9, Lines 3 to 14: It is perhaps worth pointing out that only the linear combination $\alpha DR + \beta c$ appears in these equations. Thus, the model assumes that the chemical and radiation can be treated as additive, effective stressors. This would allow comment on other modes of interaction, e.g. multiplicative or sub-multiplicative synergism.	This is a very good idea and we have added the paragraph to discuss this and suggest a sensitivity analysis to explore this in future work, exploring the significant similarities and differences in model prediction by means of a sensitivity analysis of the parameters α, β and γ of a generalised additive-multiplicative synergistic function, exploring cases of antagonism and synergism. We decided to mention this again in the conclusions as a suggestion for future work.
Page 9, Line 28: The derivation of this, in-line equation is not obvious. I suggest that it is set on a separate line and associated with a short description of how it is derived. Neither m nor CR seem to be defined.	This is simply a case of making $\kappa = \eta = p = 0$ and integrating directly the simple equation that is left. The m and CR were something that was left accidentally undefined, in the sense that in the case of equilibrium $c = mCRC_e$ where m is the mass of the animal, CR is the concentration ratio and C_e is the concentration of the pollutant in the environment. All this is now explained.
Page 9, Line 37: 'The model is able'	Done
Page 9, Line 39: 'will allow us'	Done
Page 9, Line 54: p_R has not been defined previously. Also, it is written as a function of dose rate (DR) not cumulative dose.	The text says "…the probability p_R of forsaking adaptation and instead going into successful full repair…". We would have thought this was sufficient to define what p_R means. We have modified the sentence to make it clearer. And yes, p is function of cumulative dose but cumulative dose ultimately is an integration of DR, so p(DR) is not incorrect, but anyway, we have changed it to "p =…" to make things clearer for the reviewer.
Page 10, Line 20: Here a value of 255 $m^2\ d^{-1}$ is equated to a migration rate of 8E-4 d^{-1}. Presumably, this is the area 'depopulated' by migration per unit time, but this is not stated. Nor is it clear why this is the minimum value for survival.	We have eliminated reference to the 255 $m^2\ d^{-1}$ (a sentence we took from our previous paper) as this is largely irrelevant to the present study (it was the migration rate per surface area value). The significance of $k = 8 \times 10^{-4}$ is that, for the scenario considered, this gives the minimum migration rate below which the population in the most contaminated area is tipped into extinction due to lack of the compensating influx of healthy animals from less contaminated areas. Text modified accordingly.
Page 10, Line 28: DRR has not been defined. Also, the relationship between DRR and the recovery onset time TR is not explained. In addition, no explanation is given as to why $k = 1$ is equated to a migration rate of 3.65E5 $m^2\ s^{-1}$.	*DRR* is the same as *DR*, so we corrected that. We admit that defining the onset time as that for which $X_1 = 1$ is a bit unclear, so we have changed the definition to "… the time at which the healthy population in the most contaminated area begins

Incidentally, it is not helpful to use *k* for different parameters in the sensitivity analysis, particularly as it is sometimes an absolute value and sometimes a multiplier on a base value.	to increase above a minimum of one individual". We have also explained that the case of $k = 1$ corresponds to the default migration rate per area value set in the model, or 3.65×10^5 m^2 d^{-1}. This is therefore by definition. Finally, we disagree with the need to change *k* because it does not repeat any symbol used before (we used capital *K* for the carrying capacity and κ (kappa) for one of the model parameters but never lower caption *k* before). This is, after all, very ordinarily used as a symbol for a multiplier.
Page 10, Line 50: 'healthy status'	Done
Page 13, Line 38: tipped into extinction'	Done
Page 13, Line 45: 'the damage'	Done
Page 15, Lines 21 to 23: It might be worth commenting that the development of models of this type provides an appropriate framework for formulating questions about how effects on populations are induced and expressed that would otherwise be difficult to articulate.	Very good suggestion. We copy the sentence into the paper at this point.
Page 15, Line 25: 'define a population'	Done
Page 16, Line 31: As species mobility is a key factor, further questions arise as to the viability of fragmented habitats, even when the fragments are connected by migration corridors.	Again a very good caveat and we take the liberty to copy this into the conclusions.
Page 17, Line 38: 'damage and repair'	Done