

Model results  
Scenario: Population response to  
chronic irradiation

Luigi Monte, ENEA, Italy

# The model

- *Model of mortality: Gompertz*

$$\frac{\partial y}{\partial a} + \frac{\partial y}{\partial t} = -My$$

$$M = ke^{pa}$$

- $y$  = population (age  $a$ )
- $k$  = initial mortality
- $\frac{0.693}{p}$  time for doubling mortality

# The model

- Model of population dynamics
  - 2x2 Leslie matrix
  - 2 age classes: Juvenile and adult individuals
  - Factor F to modify the death and the birth rates (death rate·F; birth rate/F)
    - $F=A*(1+(poputation(t)/KP))$
    - KP= saturation constant

# The model

- (modified) Leslie matrix

$$\begin{pmatrix} (1 - \Delta t/J_t)p_j & f_a \\ \Delta t/J_t p_j & p_a \end{pmatrix}$$

- $\Delta t$  is the time step
- $J_t$  ( $\Delta t < J_t$ ) the age at sexual maturity
- $p_j$ ,  $p_a$  and  $f_a$  are the survival of the juvenile and the adult individuals and the fertility of adults in the interval  $\Delta t$
- If  $\Delta t > J_t$  the entry [1,1] in Leslie matrix becomes 0 and entry [2,1] is  $p_j$ .

# The model

- Radiological sub-model
- Mortality is linearly related to the dose rate

$$\Delta M = C \cdot D$$

- $\Delta M$  = increase in mortality rate ( $\text{year}^{-1}$ )
- $D$  = Dose rate ( $\text{Gy year}^{-1}$ )
- $C$  = Multiplicative factor ( $\text{Gy}^{-1}$ )
- $C=0.16 \text{ Gy}^{-1}$ .

# Model parameters

- Population data (from AnAge database)

Species	Initial mortality rate (year <sup>-1</sup> )	Time for doubling mortality rate (year)	Age at sexual maturity	Average litter size	Litters per year per adult female
Mus musculus	0.01	0.3	0.12	7	5.4
Oryctolagus cuniculus	0.01	1	2	5	4.3
Canis	0.02	3	1.5	6	1
Capreolus	0.05	1.5	1.1-2	1.6	1

- Female:male ratio = 1

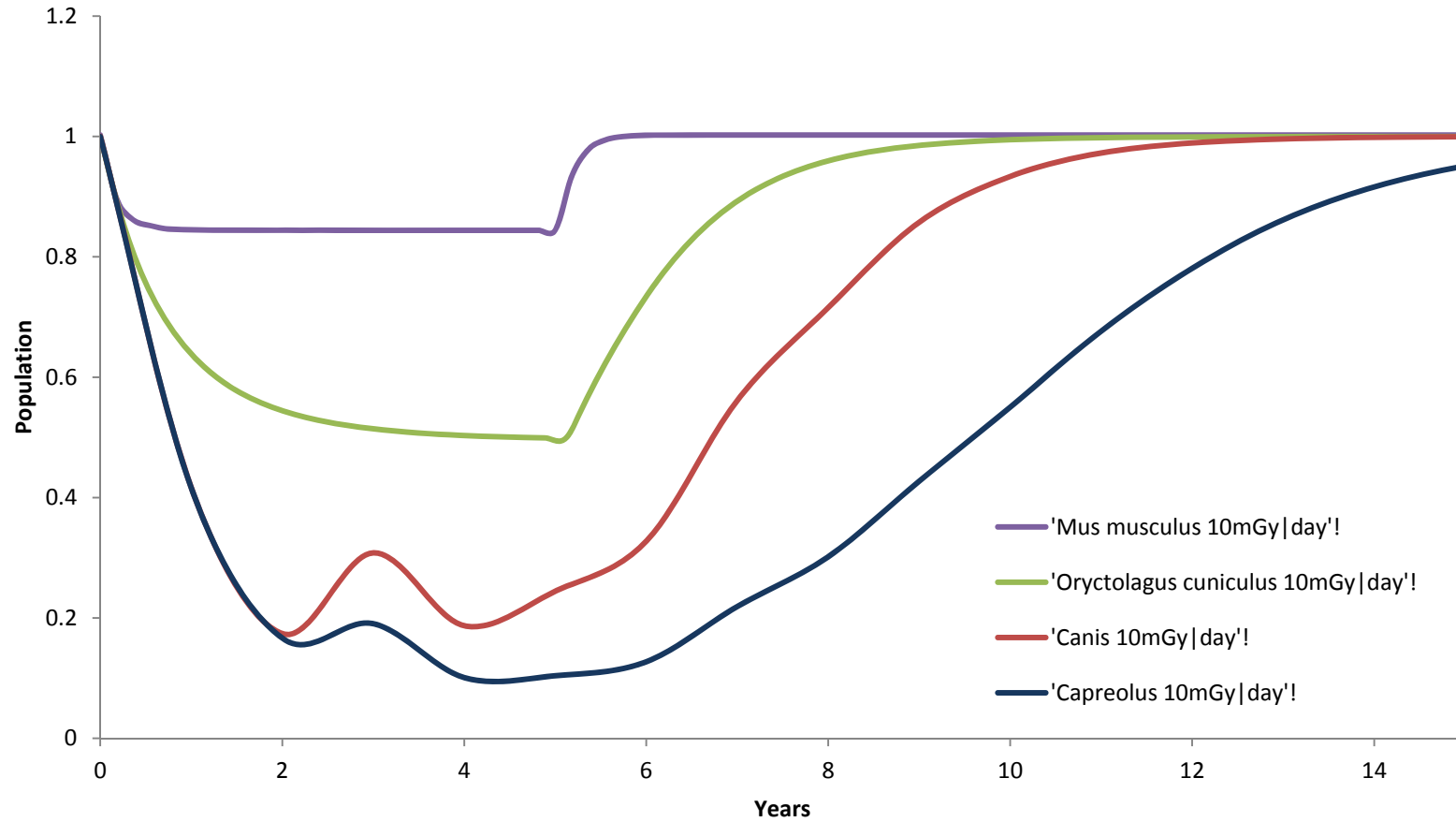
# Model parameters

- KP population “saturation” constant
- $P^*$  population at steady state
- F multiplicative factor to correct death and birth rates

Species	KP/ $P^*$	F (at steady state $P=P^*$ )	Competition level
Mus musculus	0.18	3.3	+++
Oryctolagus cuniculus	0.21	2.9	++
Canis	0.26	2.4	+
Capreolus	1.29	0.89	-

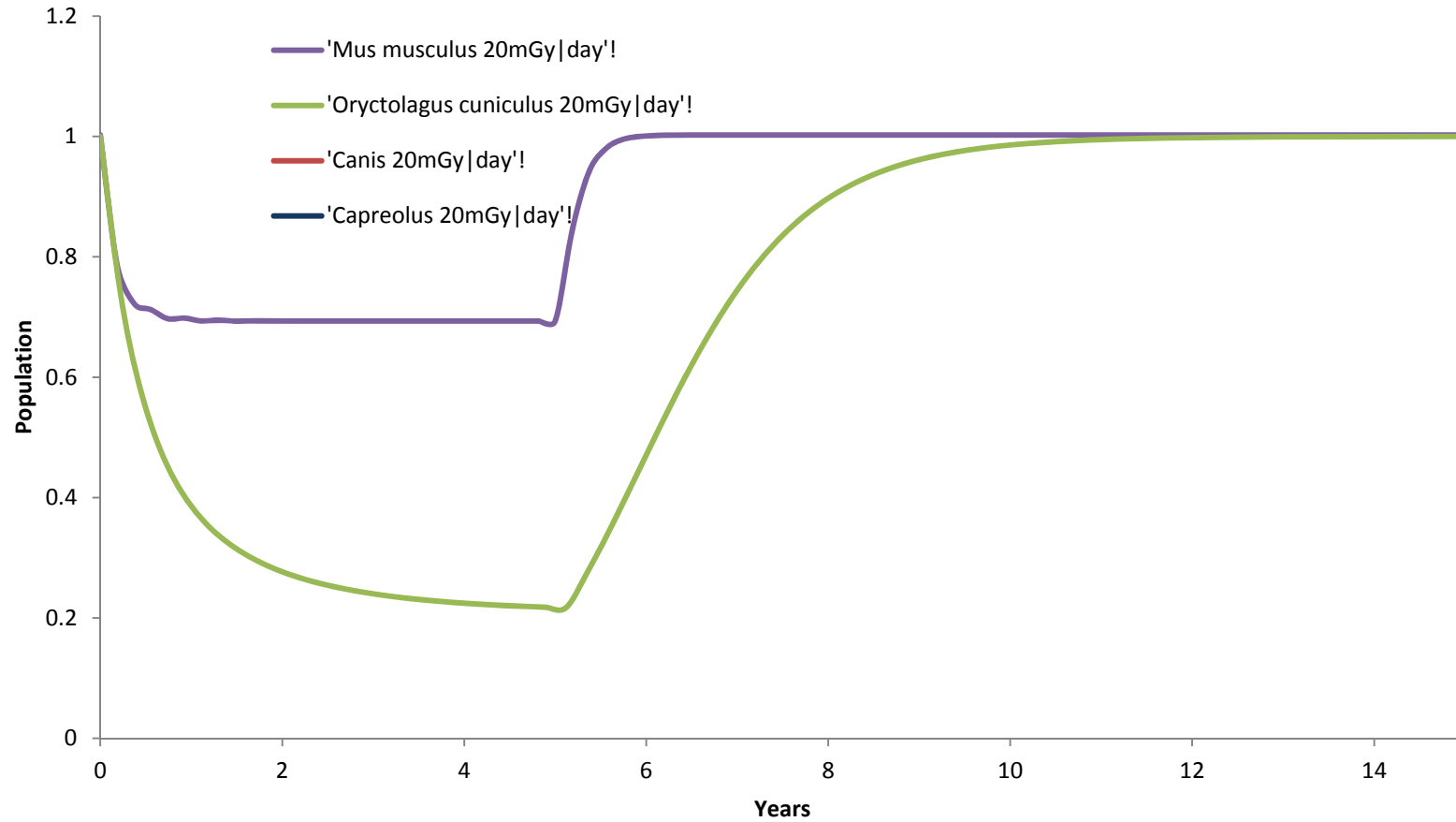
The competition level (within a species) increases when KP decreases

# Results – 10mGy/day

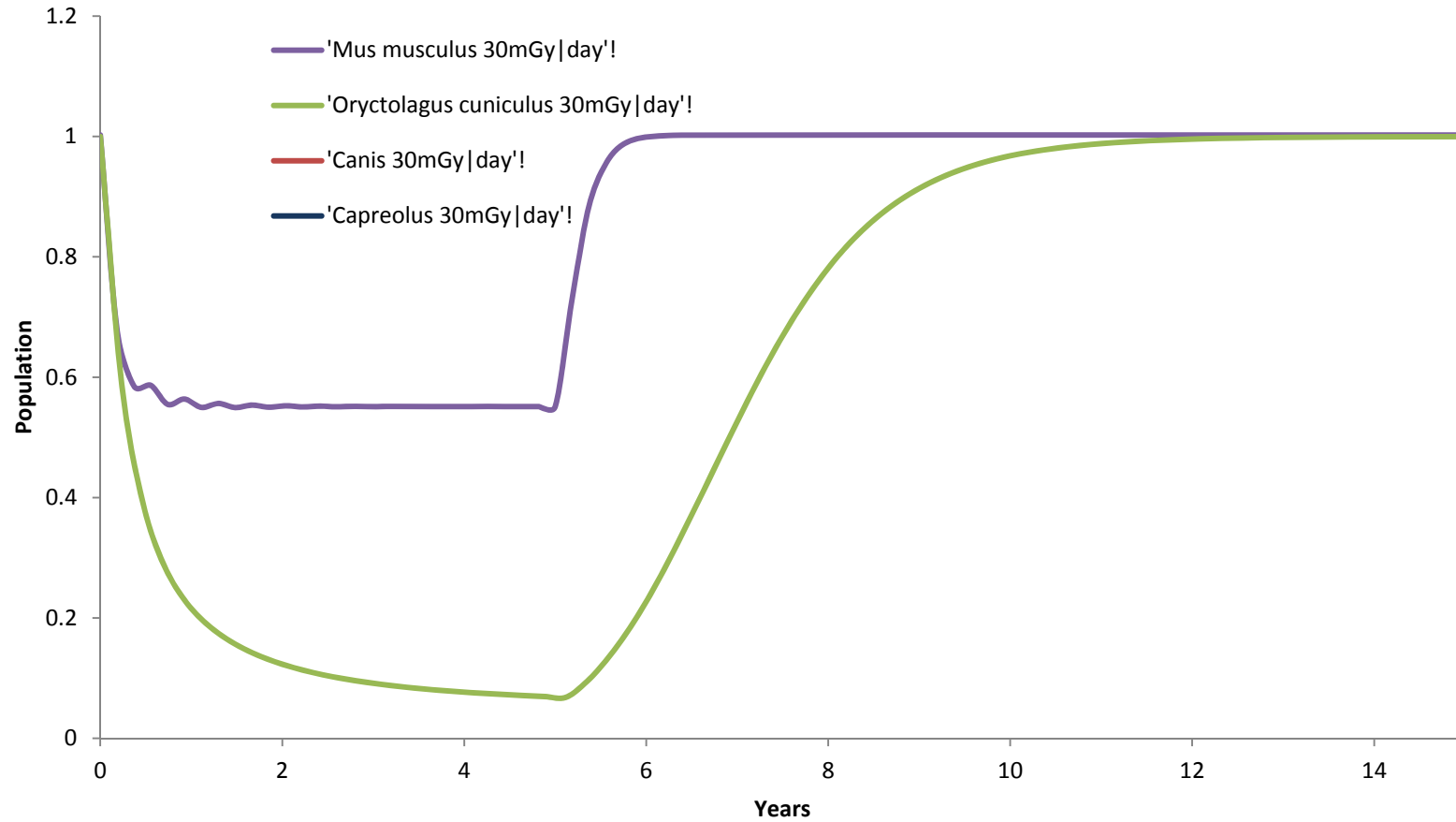




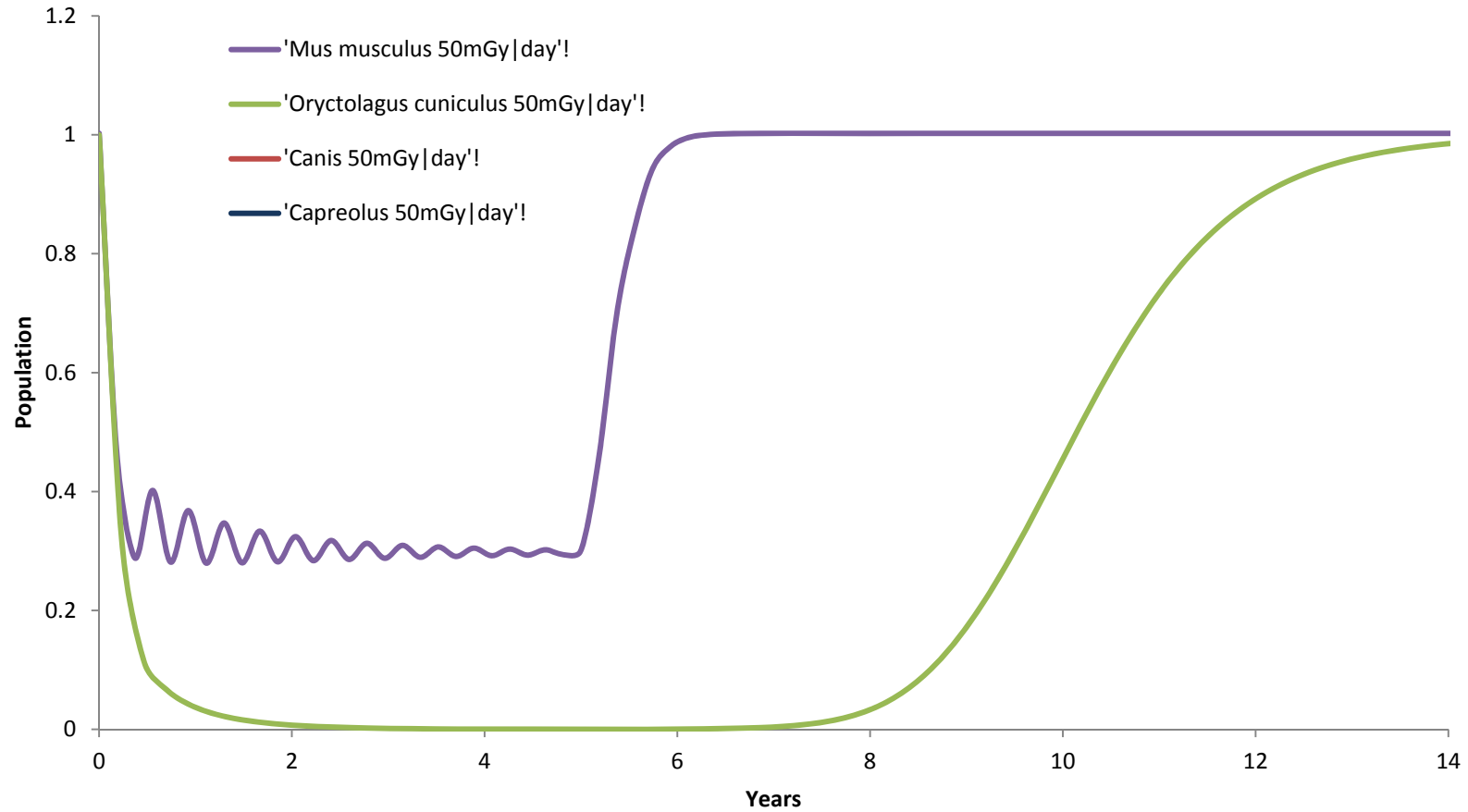
# Results 20 mGy/day



# Results – 30 mGy/day



# Results – 50 mGy/day



# Three age-group model

- $N_b$  - newborns;
- $M_n$  - individuals of age equal to the reproduction period;
- $M$  - adults.

condition

$$l_t \geq \Delta t \geq \frac{J_t}{2}$$

Leslie matrix

$$\begin{array}{ccc} 0 & 0 & f_a \\ p_b & 0 & 0 \\ 0 & p_n & p_a \end{array}$$