AAFKE SCHIPPER
DEPARTMENT OF ENVIRONMENTAL SCIENCE
INSTITUTE FOR WATER AND WETLAND RESEARCH

Modelling the costs of chemical impacts on wildlife populations

The case of peregrine falcons (*Falco peregrinus*) exposed to PBDEs

CADASTER Workshop
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Radboud University Nijmegen

Background

REACH

- Protection of human health and the environment
- Enhance innovation and competitiveness of the EU chemicals industry

→ risks versus benefits of chemicals

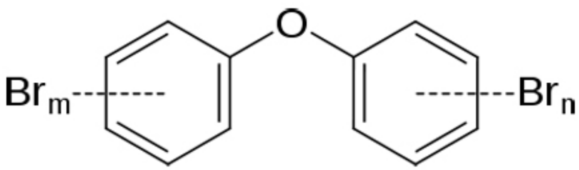
Background

- Cost–benefit analysis (CBA)
- External costs: costs not included in the market price

→ how to quantify costs of chemical impacts on non-market ecosystem properties?

Aim

Quantify the costs of chemical impacts on wildlife populations



?

Approach

- Matrix population model
- Year-to-year population dynamics based on a **transition matrix**
- Vital rates: growth, survival and fecundity per age/stage class
- Vital rates influenced by population density and exposure to chemicals

→ transition matrix as function of population density and exposure concentrations

Approach

- Dominant eigenvalue of the transition matrix is the population growth rate λ
- Right eigenvector of the matrix is the stable age or stable stage distribution

→ calculate equilibrium population per toxicant exposure concentration:
solve the transition matrix for $\lambda = 1$

→ if equilibrium population < user-defined minimum:
calculate number of individuals needed to restore the equilibrium population

→ replacement costs

Case study

Costs of PBDE impacts on a population of peregrine falcons

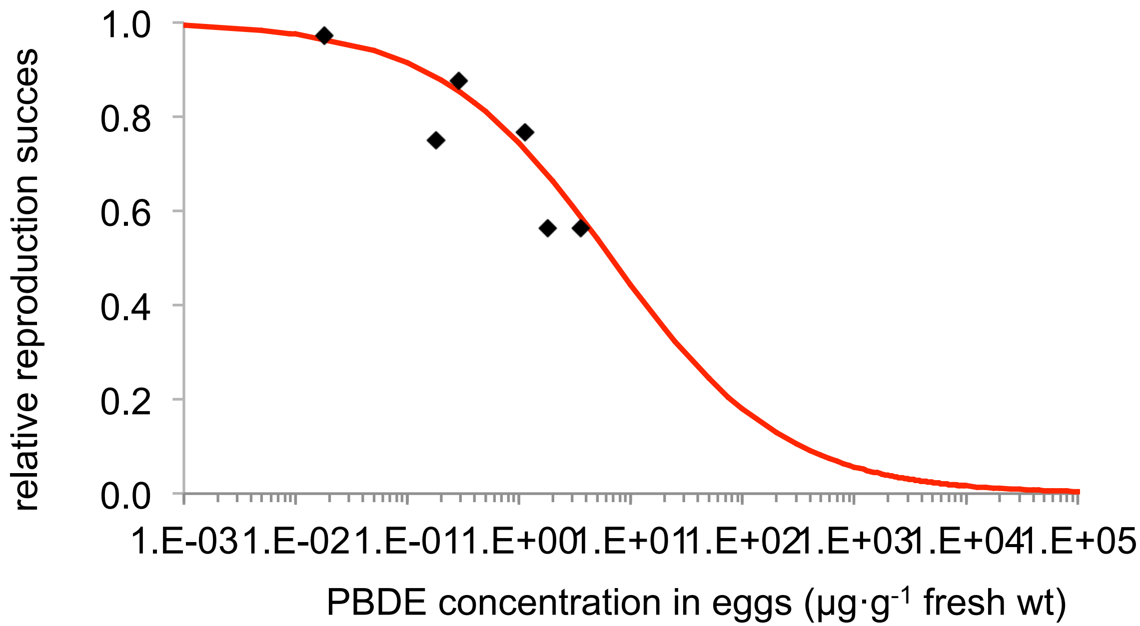
Why this case?

- Data availability
  - population parameters
  - exposure concentrations
  - toxicological data
  - replacement cost estimates

- High PBDE concentrations in eggs

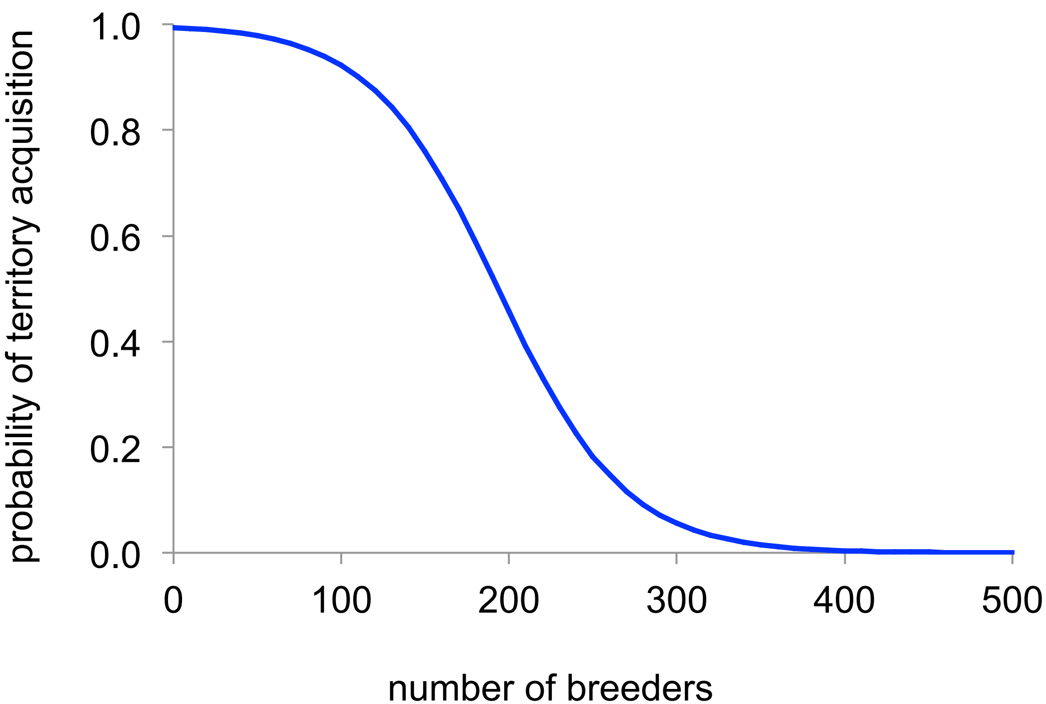
Case study – transition matrix

- Three life stages: juveniles, non-breeding birds, breeders
- Fecundity modelled as function of exposure to PBDEs



Case study – transition matrix

- Density-dependence modelled as the probability of a non-breeding bird to aquire a breeding territory



Case study – transition matrix

Transition matrix

$$A = \begin{bmatrix} 0 & S_{nb}F_C P_b & S_b F_C \\ S_j & S_{nb}(1-P_b) & 0 \\ 0 & S_{nb}P_b & S_b \end{bmatrix}$$

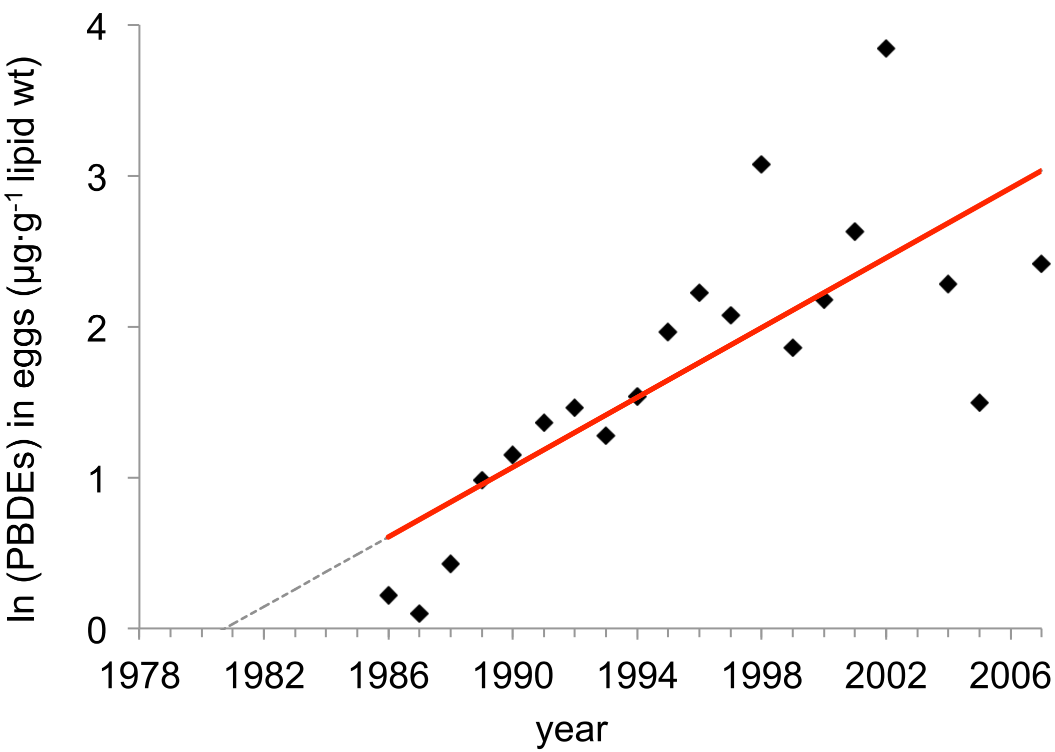
F fecundity
S survival
P_b probability of a non-breeder to acquire a breeding territory

j juvenile
nb non-breeding sub-adult
b breeding adult

Case study – model testing

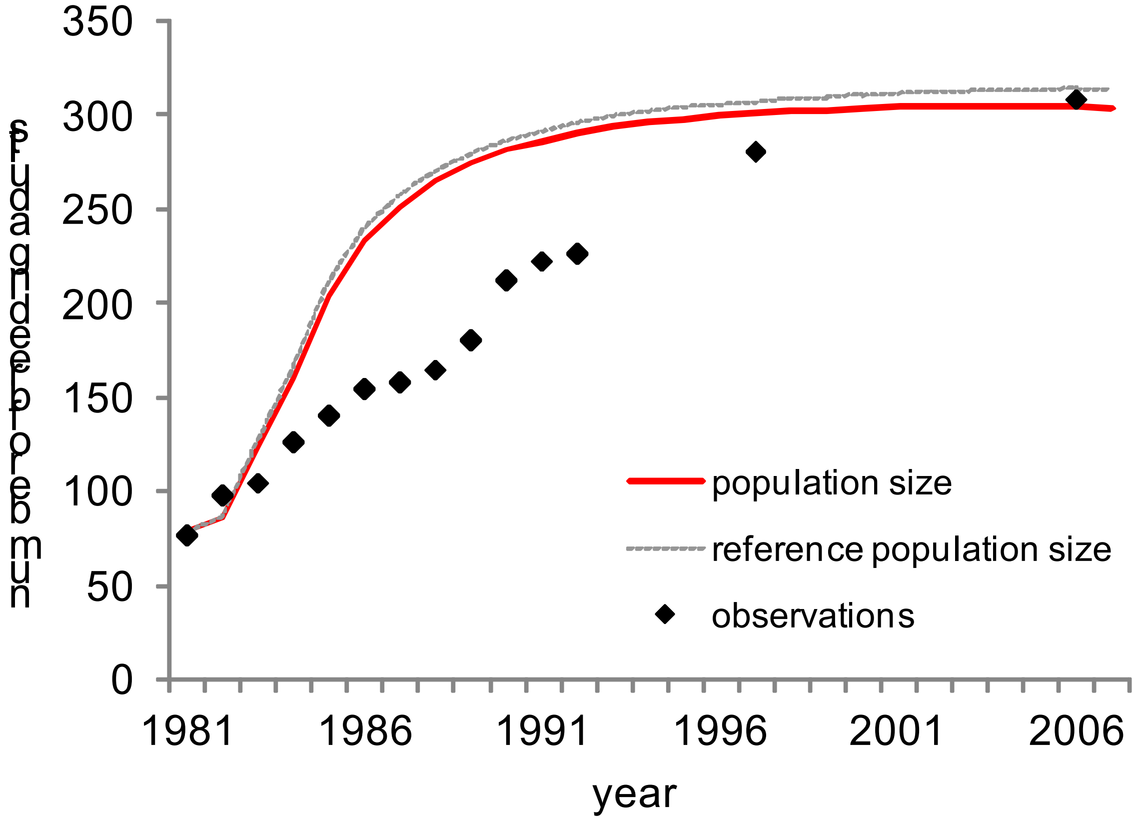
- Simulate population from 1981 through 2007 and compare with observations

- Exposure concentrations:



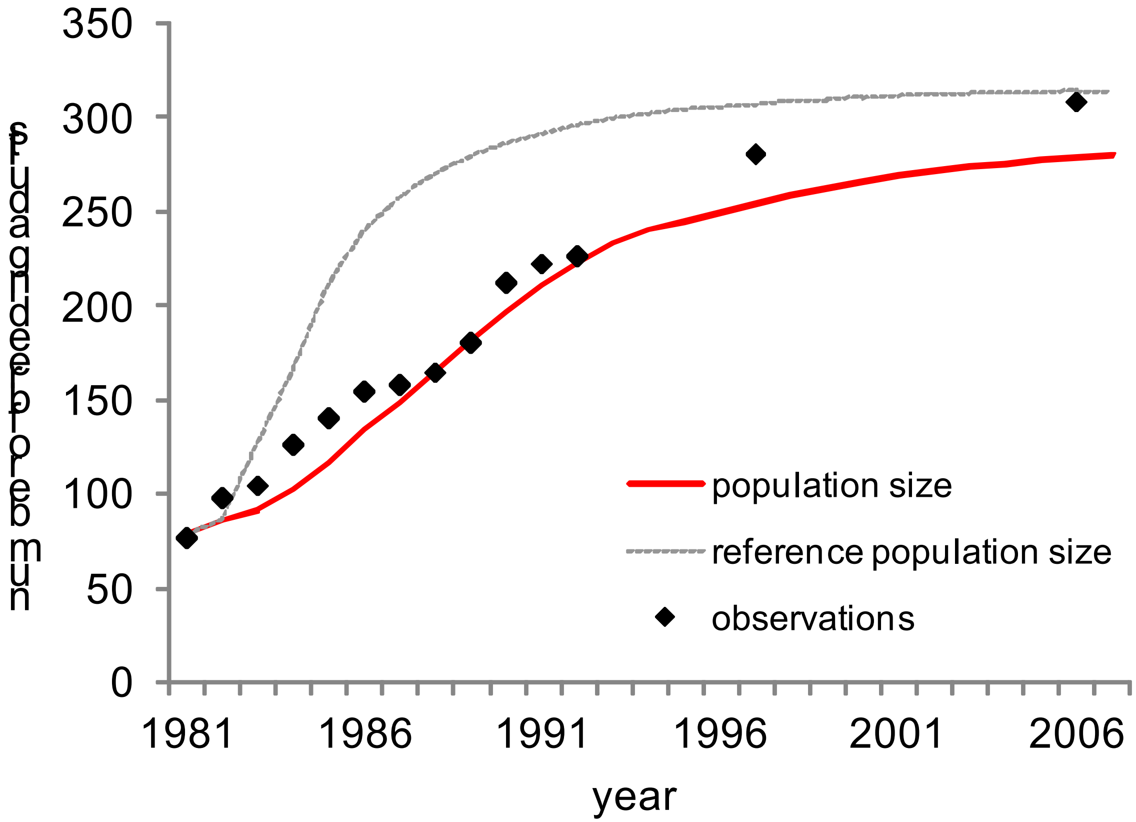
Case study – model testing

- Population development as function of exposure to PBDEs:



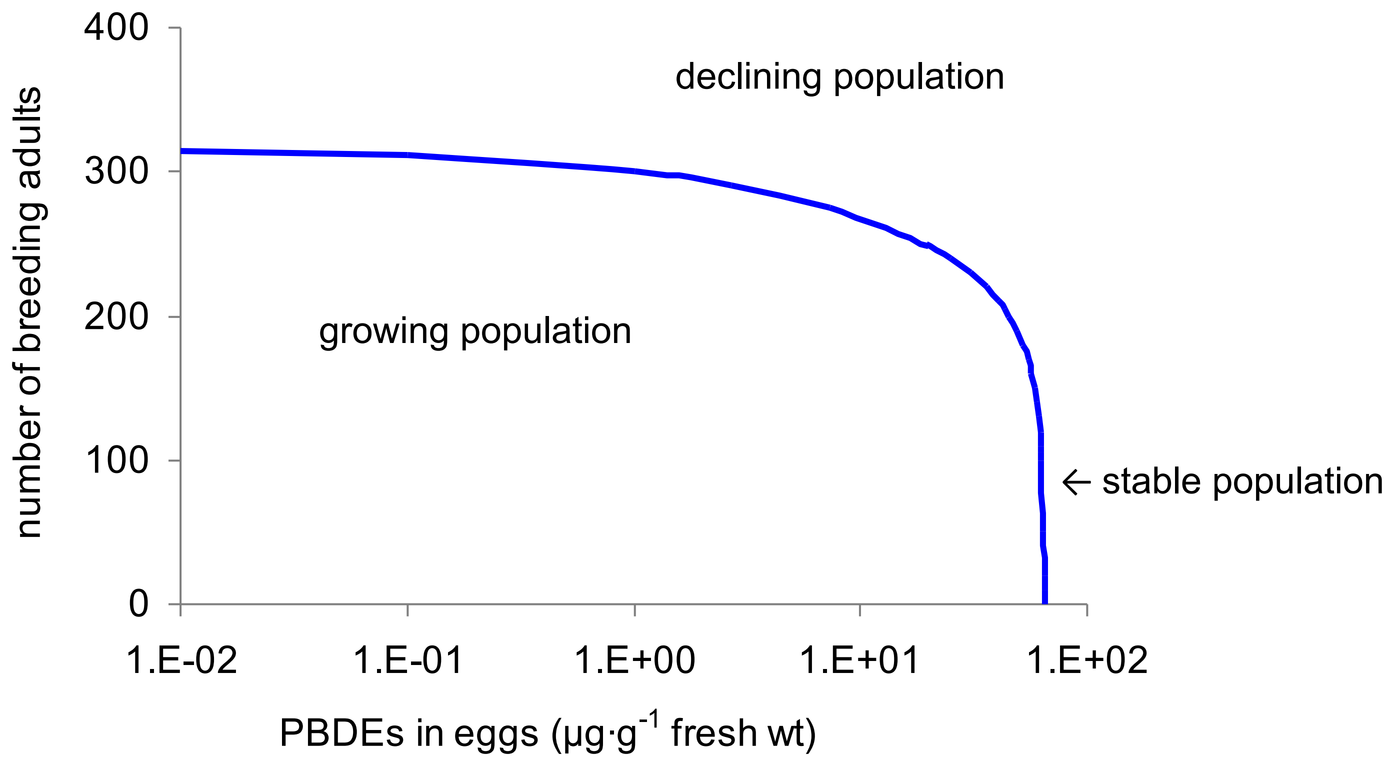
Case study – model testing

- Population development as function of exposure to PBDEs and DDE:



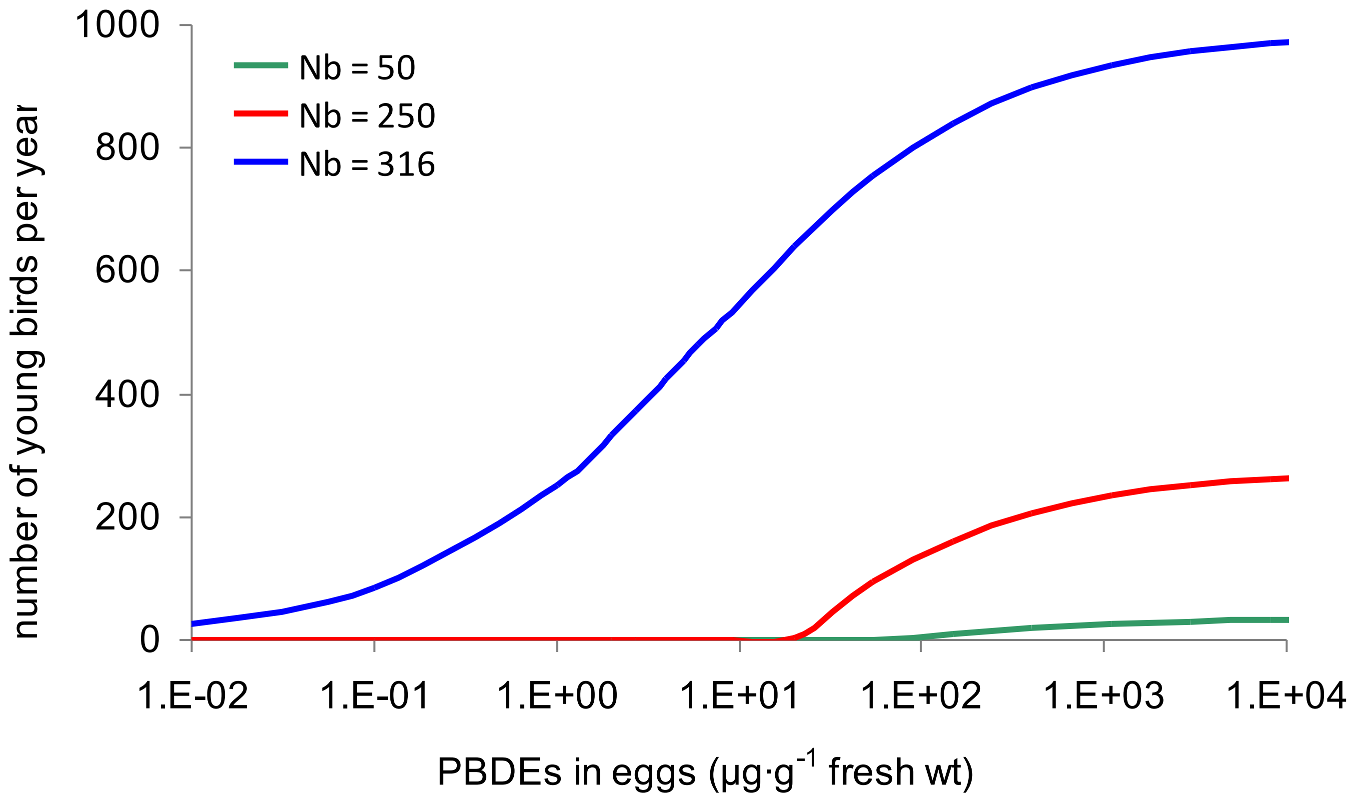
Case study – results

Equilibrium population size (breeders) in relation to PBDE exposure



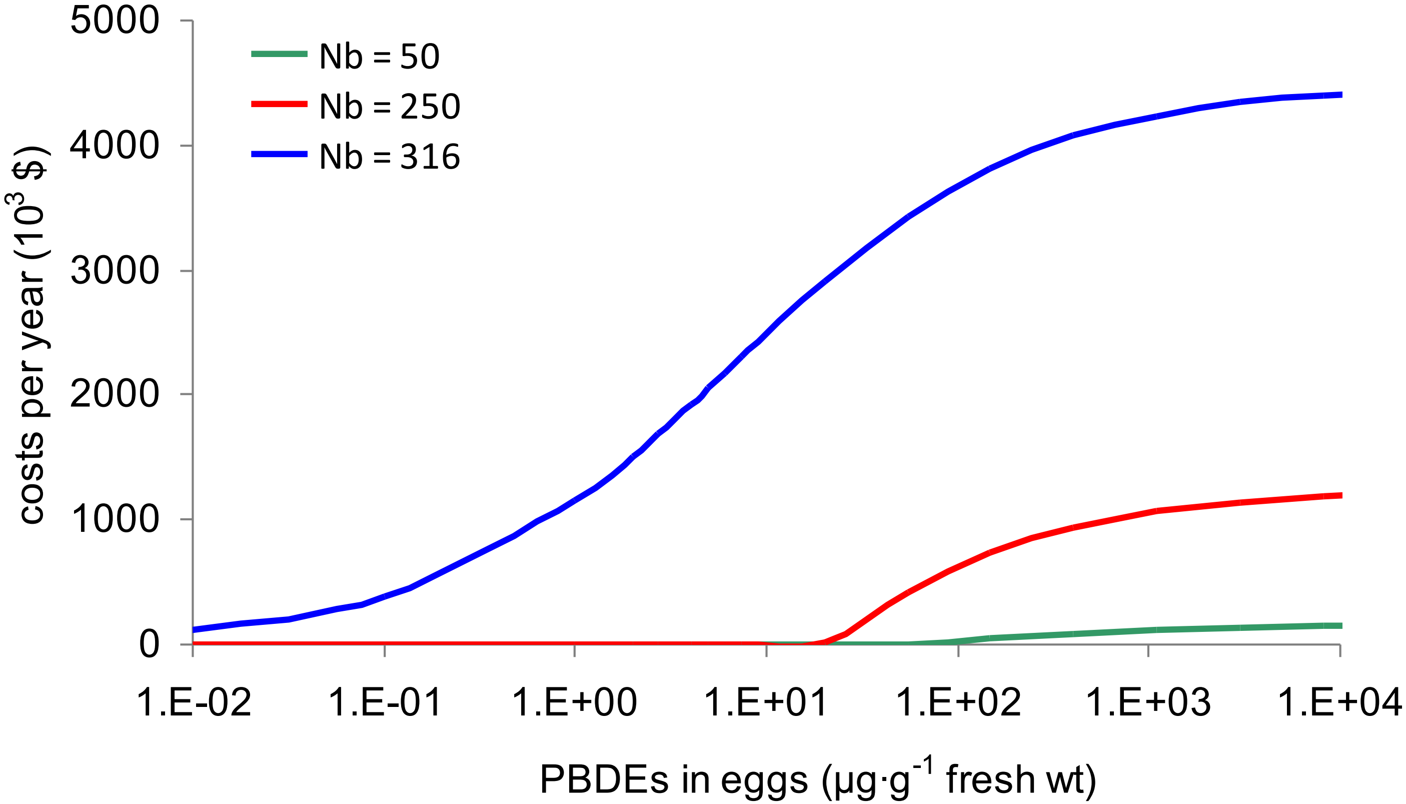
Case study – results

Number of young birds needed per year



Case study – results

Costs per year



Conclusions

- Quantitative approach to calculate replacement costs
- Results are population-specific:
  - population parameters (fecundity, survival, density-dependence)
  - concentration-response curve (EC50 and slope)
  - replacement costs per individual
- Density-dependence may mask toxicant impacts on wildlife populations
- Multi-stressor approach needed

Outlook

- Application to other species
- Application to other stressors (including interactions)

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