

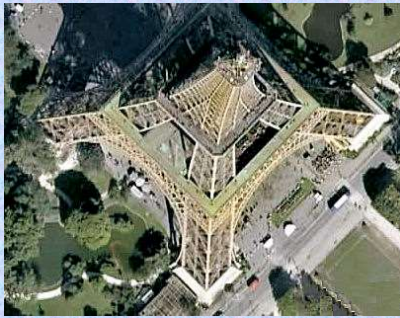
Accounting for incomplete detection Capture-recapture, Occupancy

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A Personal Overview of Capture-recapture models (and more...)



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Main points

- From Pattern to Processes
 - Flexibility of Multistate approach
 - Environmental covariates *sensu lato*
 - Long term programs
 - Further CMR models (Cf EURING 2023)
- Anthropogenic changes and exploited populations
 - The theory of exploited populations
 - Traditional links with population dynamics models
 - Integrated population models
- A few thoughts on modelling

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The flexibility of Multistate/Multievent Models

- From questions and data available, define states
 - Sites ? Reproductive states ? Competing events ?
 - A mix ?
 - Use non-observable states if needed
 - State uncertainty at (re)capture? (i.e. multistate or multievent?)
- Make choices to set up a general model
 - Time dependence, Age dependence
 - Groups, adult and young, etc...
- Proceed as much as possible in a step-down way
 - Check goodness-of-fit / use conservative c
 - Run this general model (repeated runs!)
 - Build constrained models directed to biological questions
 - Beware of identifiability and other numerical problems
 - Discuss estimates of final model (only!)

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Environmental covariates *sensu lato*

- Meteorological variables
- Anthropogenic covariates (e.g. hunting bag)
- One-sided tests if clear prediction
- Protect regression
 - Too few covariates ⇒ too large unexplained environmental variation
 - Too many covariates ⇒ spurious relationships
 - Avoid stepwise regression, use PCA of covariates

V. Grosbois, J.-M. Gaillard, Roger Pradel, C. Barbraud, J. Clobert, et al.. Assessing the impact of climate variation on survival in vertebrate populations. *Biological Reviews*, 2008, 83 (3), pp.357-399. [10.1111/j.1469-185X.2008.00047.x](https://doi.org/10.1111/j.1469-185X.2008.00047.x) . hal-03515165

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Long term programs

When modelling the effect of climate change, the major source of uncertainty is in the demographic parameters – climate covariates relationships

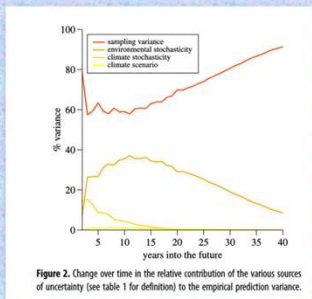



Figure 2. Change over time in the relative contribution of the various sources of uncertainty (see table 1 for definition) to the empirical prediction variance.

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Further CMR models

- Heterogeneity (capture, survival...)
- Dependency among individuals (kinship, spatial dependency)
- Individual covariates
- Random effects
- ...



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Anthropogenic changes and exploited populations


- The theory of exploited populations
 - Man-induced extra-mortality
 - Explicit (quarry species), or implicit (diffuse impacts)
 - Compensation or additivity
 - A variety of other concepts (reproductive value...)
- Traditional links with population dynamics models
 - Time-Varying matrix models and visual comparison
- Integrated population models
 - Combine in a single likelihood the CMR information and the population survey information (pop. Size, age structure,...)
 - Complex models, Bayesian approaches, not fully stabilized

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A few thoughts on modelling

- Models (statistical models, matrix models...) are tools to answer questions, not beautiful and fancy representations of reality
- There is no good or bad model; there are useful, less useful, or useless models

Would you say a hammer is good or bad ?



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A few thoughts on modelling

- Models are tools to answer questions, not beautiful and fancy representations of reality
- There is no good or bad model; there are useful, less useful, or useless models
Would you say a hammer is good or bad ?
- Data have not been generated by models: the best you can hope is that **on some selected criteria**, outputs of the model behave like the real world
- Do not expect a model to be exhaustive
"Models are playthings relative to reality"
R.M. Cormack

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How to proceed

- Bottom-up approach
 - To understand which result comes from which model feature
 - For better communication / publication
 - To keep focus on your questions

"Modeling is the art of oversimplification"

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