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Introduction to IPM

First things to know about IPM

- IPM = Integrated Population Model
- Use in studies focusing on population dynamics
  - Population dynamics = changes in abundance over time and demographic causes of these changes
- Strength : combine different available data sets to get deeper insights into population dynamics and better estimates of the demographic traits

$$N_{t+1} = N_t \times g(s, f)$$

t = year, s = survival, f = productivity

3 main benefits from this method

- IPM includes information about demographic rates both from
  - Explicit data (e.g. mark recoveries for survival)
  - Data on population size

  => estimation of demographic rates with increased precision which will improve population size estimates

- Case of missing data : demographic rate can be estimated from data on population size

- Simultaneous study of demographic rates and population size allow a comprehensive assessment of the cause of population changes

Development of an IPM : 3 theoretical steps

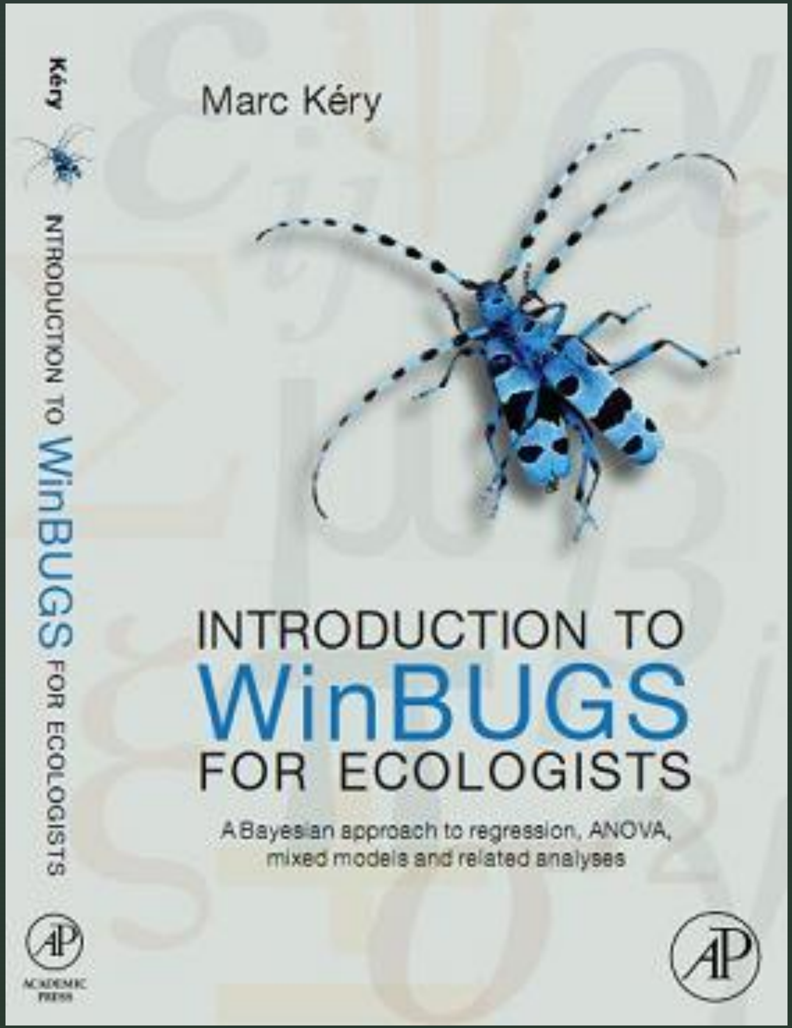
- 1st: develop a population model that links the demographic rates with changes in population size

- 2nd: write the likelihood of all data sets available

  Counts, Survival, Productivity, Immigration, …

- 3rd: construct the joint likelihood of the complete model

Want to start ?



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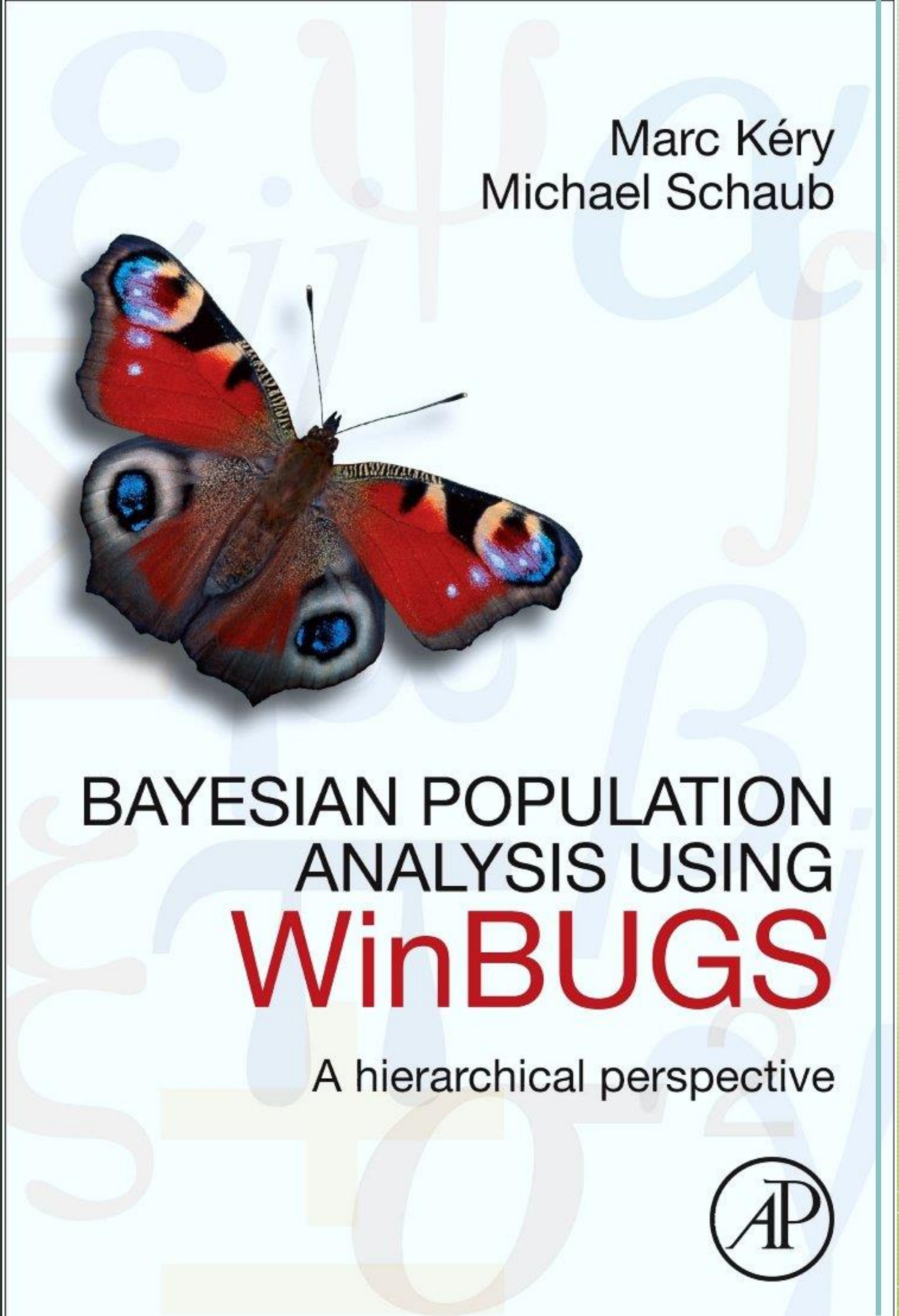


Step 1: Define the link between changes in population size ans demographic rates

- E = expected number

$$E(N_{1,t+1} \mid N_{1,t}, N_{ad,t}) = N_{1,t} * S_{juv,t} * f_t + N_{ad,t} * S_{juv,t} * f$$

$$E(N_{ad,t+1} \mid N_{ad,t}) = N_{1,t} * S_{ad,t} + N_{ad,t} * S_{ad,t}$$

Step 2: Define the likelihoods of each Individual Data Set

- **Population counts**

Sources of uncertainty: we include demographic stochasticity using appropriate distributions to describe the number of individuals at year t+1

$N_{1,t+1} \sim \text{Poisson}(N_{1,t} * S_{juv,t} * f_t + N_{ad,t} * S_{juv,t} * f)$

$N_{ad,t+1} \sim \text{Binomial}(N_{1,t} + N_{ad,t} , S_{ad,t})$

- **Capture-Recapture data**

Modelisation of survival, matrix of capture-recapture

- **Reproductive success**

e.g. birds survey: number of nestlings, number of surveyed broods, productivity

Step 2: Define the likelihoods of each Individual Data Set

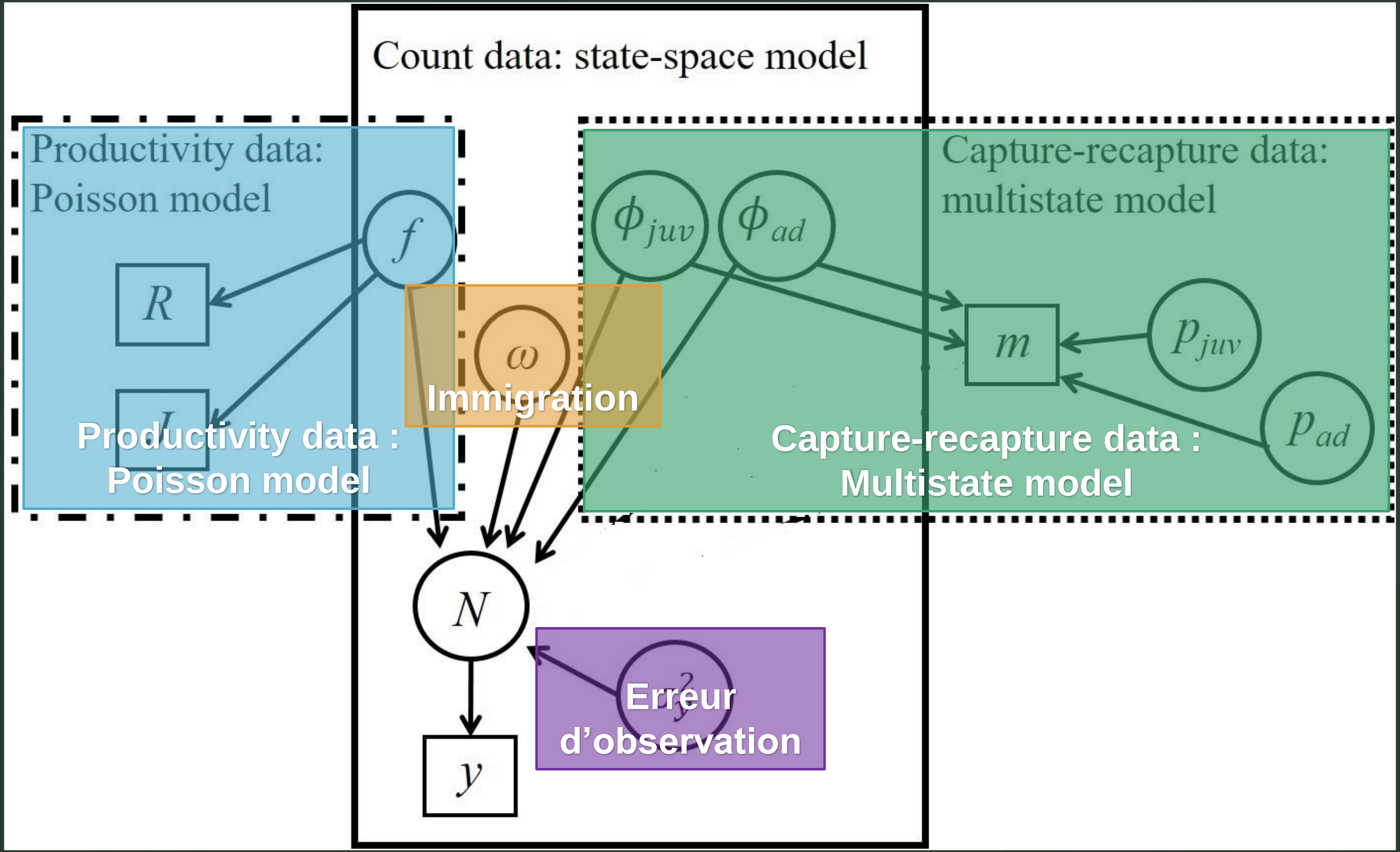
```
# 3.3. Likelihood for productivity data: Poisson regression

for (t in 1: (nyears - 1)) {
   J[t] ~ dpois ( rho[t] )
   rho[t] <- R[t] * f[t]
   }
}
```

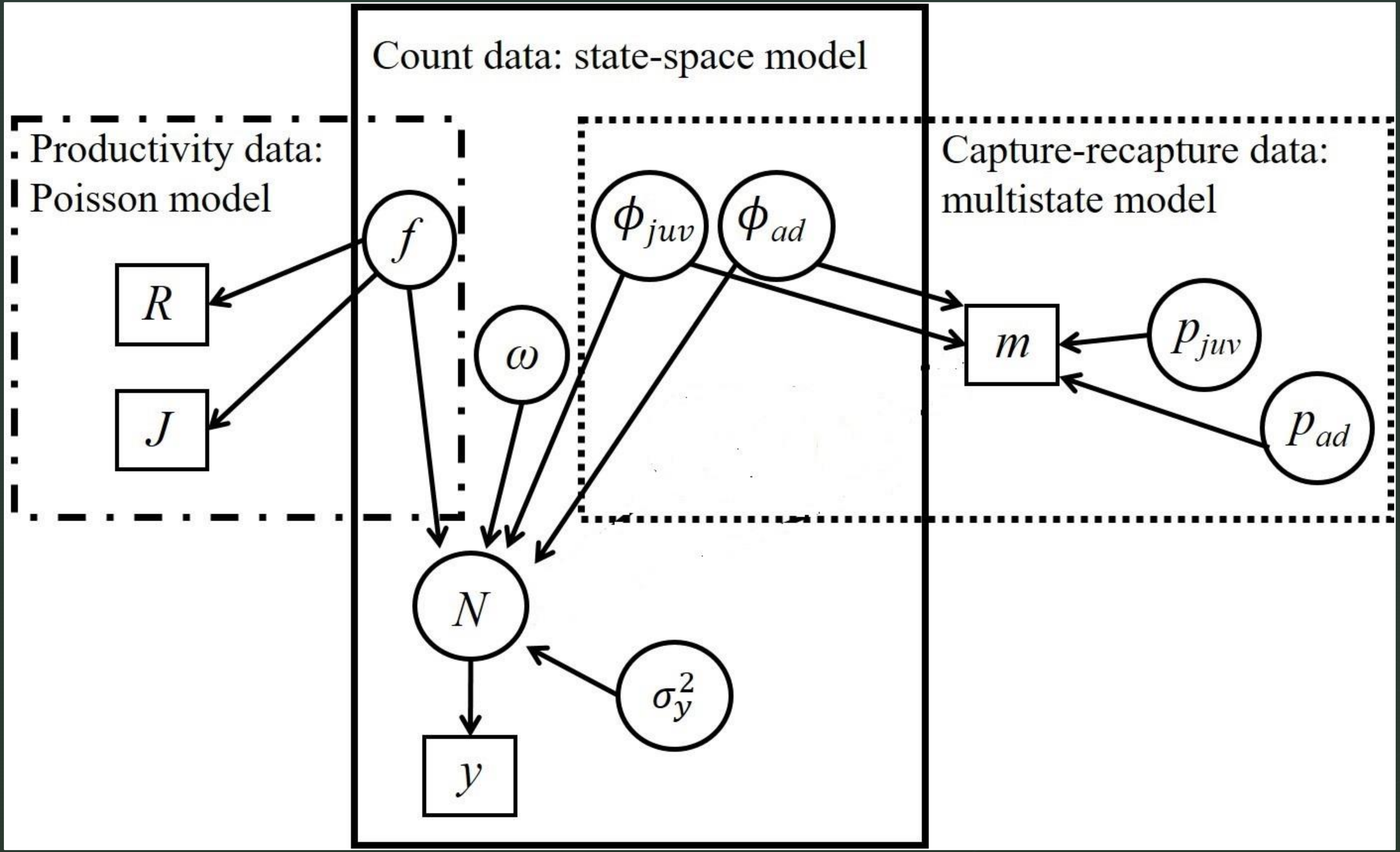
- **Reproductive success**

e.g. birds survey: number of nestlings, number of surveyed broods, productivity

Step 3: Formulate the joint likelihood



Step 3: Formulate the joint likelihood



Example with a simple IPM including counts, capture-recapture, reproduction

- Need for WinBugs or Jags (also for Linux) !!!!
  - https://www.mrc-bsu.cam.ac.uk/software/bugs/the-bugs-project-winbugs/
  - https://sourceforge.net/projects/mcmc-jags/

- Use R instead of R Studio ! Too many errors !

Real data example: Hoopoe population dynamics