Understanding & Implementing Bayesian Ecological Modelling: a Course from Beginnings to Hierarchical Complexity (5 ECTS)

8-19 April 2024 IRL (with an online option and a couple of zoom lectures)
Course Teachers: Matt Low & Malin Aronsson – Department of Ecology, SLU

Rationale:

Bayesian analyses are becoming increasingly widespread in Ecology and the Life Sciences because: (1) they are able to account for the true uncertainty in parameter estimates, (2) they incorporate prior information that allow estimates to be updated as a discipline progresses, (3) hierarchical models are easily constructed that allow the ecological process to be represented, rather than it being squeezed into a pre-defined statistical model format, and (4) they use probability distributions in a way that allow estimates of interest to be expressed as probabilities, rather than an overly-simplistic 'significant' versus 'non-significant' approach. Thus, students need to understand how these approaches work and when they should be used. If taught correctly, it is clear that Bayesian analyses are more intuitive and easier to understand that 'traditional' statistical analyses.

Basic Course Structure:

The main part of this course will be interactive and occur over 2 weeks, with some pre-course material that students need to watch or read prior to this. The course will be based around understanding the principles of Bayesian analyses and how they are derived from common-sense ideas about probability….and then how to use this understanding to build all sorts of cool models. Much of this will be based around real world problems and data, where students will program their own models in-class using the programming language R.

Intended Learning Outcomes:

Students will have a grounded understanding of (1) how Bayes rule is derived from the principles of probability, (2) the advantages of Bayesian analyses and when they should be used, (3) how MCMC works and why it is necessary for many Bayesian analytical problems, (4) the probability distributions needed for bringing their data to ecological models (Gaussian, Poisson, Binomial, Gamma, Beta, Bernoulli), (5) how to interpret and communicate information contained in the posterior distribution, (6) how to think about model structure and directly translate your ideas into programmed statistical models, (7) how to use R and JAGS to run their models, & (8) how to interpret and report their findings. The course will assume no prior knowledge of Bayesian statistics but will require that students are able to use R and have a basic understanding of R programming principles (e.g. loops, indexing etc).

Course Lesson Topics:

(1) Bayes Theorem, (2) Probability distributions, (3) The basics of linear models, (4) creating and formally describing models, (5) using JAGS, (6) predictions and derived variables, (7) interactions, centring and polynomials, (8) model fit, (9) non-linear models, (10) hierarchical models, (11) offsets and over dispersion, (12) model selection, (13) dealing with missing data, (14) zero-inflation and occupancy modelling

Course Credits:

Students will receive 5 ECTS points (the equivalent of ~3.5 weeks work).

Teachers:

The course will be taught and programming exercises monitored by Matt Low and Malin Aronsson. Both have been increasingly using Bayesian analyses in their work for the past 10 years. Matt & Malin have been teaching the Bayes course since 2016.

Assessment:

The course will be structured around the principles of formative assessment. This means that there will be no end-of-course assignment or exam to complete: rather the teachers will continuously assess the students during the course. The advantage of this approach is that students who understand material quickly can be given more challenging exercises to progress with, while students who are having trouble understanding key concepts can be given more time and additional exercises to help them understand before moving on. This ensures all students work to their ability to gain the most out of the course as they can. Thus passing the course will be determined by attendance and work ethic, rather than an arbitrary achievement level.

Course Style:

The course environment is relaxed and fun (well, as much fun as it can be when programming Bayesian models), with students encouraged to work both independently and within small groups to help problem-solve modelling issues. This encourages the student to understand how to solve problems when working under different working conditions and encourages communication and collaboration. Both teachers will be available during the main course period to offer encouragement, clarifying concepts and helping students solve problems as they arise.