

# Introduction to Bayesian Statistics in Life Sciences- FNR 6560

## 1 Overview

**Instructor:** Denis Valle, 408 McCarty Hall C, 352-392-3806, [drvalle@ufl.edu](mailto:drvalle@ufl.edu)

- Please use the Canvas message/Inbox feature for fastest response.
- Office hours: Tuesdays right after class.

**Teaching Assistant:** Henrique Shirai, [henrique.shirai@ufl.edu](mailto:henrique.shirai@ufl.edu).

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**Semester, time and location:** Spring semester, period 5 (11:45 am - 12:35 pm) on Tuesdays and periods 4-5 (10:40 am - 12:35 pm) on Thursdays. This will be **online synchronous** course, which means that students are expected to participate through zoom during these days and times.

**Credits:** 3

Bayesian statistics have been extensively adopted and used in multiple scientific fields due to the flexibility of the models that can be created in this framework. In particular, the Bayesian framework has enabled modelers to create customized models to tackle large and complex statistical problems that often times cannot be dealt with in a frequentist setting. Finally, Bayesian model results have a much more straight-forward interpretation than their frequentist counterparts.

The aim of the course is to introduce life scientists to Bayesian statistics. We will explore basic ideas regarding integration through simulation (Monte Carlo integration), the philosophy and strengths of Bayesian statistics, and the Markov Chain Monte Carlo (MCMC) algorithms needed to fit such models. We will focus on several real-world examples and how to transform these problems into statistical models. This course will rely on substantial extra-class work, in order to provide students with extensive hands on experience on conceptualizing, implementing, and interpreting the results of these models. Ideally, this experience will be enough to enable students to develop their own Bayesian models after this course is over. We will try to cover simple, mixed effect and multi-level regression models but this will fundamentally depend on the speed with which the class is able to follow the course. Implementation of these models will be done both with JAGS as well as customized R code.

**Textbook(s) and/or readings:** There is no required text for the course. Readings will be provided for each learning topic as listed in section 5, Readings.

**Required software:**

- R, freely available at <http://www.r-project.org>
- JAGS, freely available at <http://mcmc-jags.sourceforge.net/>

- A text editor, such as RStudio (<http://www.rstudio.com/>)

**Course Prerequisites:** none

- Conceptual understanding of integrals
- The student should be comfortable with the following programming skills:
  - creating and manipulating vectors and matrices,
  - creating loops and your own functions,
  - creating queries using Boolean logic
- STA6166, STA6093, or a similar introductory statistics course are highly recommended.
- It is highly recommended for students to have had a previous course on mathematical statistics, such as:
  - “ZOO6927 Statistical Principles for the Biological Sciences” by Jose Ponciano;
  - “STA 5325 Fundamentals of Probability”; or
  - “Foundations of Probability & Math Statistics: a scientific computing approach” by Nikolay Bliznyuk

## 2 Learning Outcomes

At the end of this course, each student will be able to:

- Solve real problems: think through a problem and how to translate that into a biologically sensible statistical model (instead of pre-built standard models).
- Interpret MCMC output.
- Implement Bayesian models in JAGS.
- Read and modify R code that implements a Gibbs sampler from scratch.

## 3 Course Logistics

My philosophy is that you learn best by doing, thus this course is heavily based on extra-class work and reading.

**Technology Requirements in addition to software:**

- A computer or mobile device with high-speed internet connection.
- A headset and/or microphone and speakers; a web cam is suggested.
- Latest version of web browser. Canvas supports only the two most recent versions of any given browser.

### 3.1 Assignments & Deliverables

**Participation**

I expect students to read the lecture notes and watch the recorded lectures (if available) before-hand and actively participate during class.

**Weekly Assignments**

Weekly assignments should be handed-in as word or pdf documents, basically showing how you solved the different problems (include your commented code) and the final results, together with their

interpretation. All assignments are graded from 0 to 1 and the overall grade for these assignments is the arithmetic average of all grades. I will provide my answers/code to solve the assignments with the goal of helping students identify and correct the mistakes they have made.

## 3.2 Grades & Grading Scale

80% Weekly Assignments (individual problem set & group work)

20% Participation

For information on current UF policies for assigning grade points, see

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

### Grading Scale (%)

A	90-100
A-	86.7-89.9
B+	83.3-86.6
B	80-83.2
B-	76.7-79.9
C+	73.3-76.6
C	70-73.2
C-	66.7-69.9
D+	63.3-66.6
D	60-63.2
D-	56.7-59.9

## 4 Course Content

A tentative schedule of topics to be covered in each week is given below:

Week	Topic
1	Intro. frequentist and Bayesian statistics Review: Joint, conditional and marginal probabilities; law of total probability; Bayes theorem
2	Review: Likelihood, pmf/pdf and their characteristics (e.g., moments), MLE
3	Conjugate likelihood-prior pairs: simple examples
4	Monte Carlo integration
5	Gibbs sampling and full conditionals
6	Introduction to conceptual (generative) models / generating fake data Inverse modeling
7	JAGS and linear models
8	Estimating population size from mark-recapture data
9	Metropolis-Hastings algorithm
10	Predictive distribution and sources of uncertainty
11	Linear robust regression
12	Models with latent variables
13	Multilevel models
14	Common problems in JAGS (bad initial values and identifiability issues)

## 5 Reading List

Textbooks (Not required): sections of these books will be used and will be made available when needed to registered students.

- P. D. Hoff. 2009. A first course in Bayesian statistical methods. Series: Springer Texts in Statistics. Chapters 1 (Introduction and Examples) and 9 (Linear regression).

- Michael A. McCarthy. 2007. Bayesian methods for ecology. Cambridge University Press. Chapters 1 (Introduction), 2 (Critiques of statistical methods), and 5 (Regression and correlation).
- Andrew Gelman and Jennifer Hill. 2007. Data analysis using regression and multilevel / hierarchical models. Cambridge University Press. Chapters 8 (Simulation for checking statistical procedures and model fits) and 12 (Multilevel linear models: the basics)
- Allen B. Downey. 2012. Think Bayes: Bayesian statistics made simple. Green Tea Press (available at <http://www.greenteapress.com/thinkbayes/>). Chapter 1 (Bayes' theorem)
- Benjamin Bolker. 2008. Ecological models and data in R. Princeton University Press. Chapter 4 (Probability and stochastic distributions for ecological modeling)
- Robert Winkler. 2003. An Introduction to Bayesian inference and decision. Probabilistic publishing. Chapter 2 (Probability: measuring uncertainty)

## 6 Policies and Requirements

This syllabus represents current plans and objectives for this course. As the semester progresses, changes may need to be made to accommodate timing, logistics, or to enhance learning. Such changes, communicated clearly, are not unusual and should be expected.

### 6.1 Late Submissions & Make-up Requests

Computer or other hardware failures, except failure of the UF e-Learning system, will not excuse students for missing assignments. Any late submissions due to technical issues **MUST** be accompanied by the ticket number received from the Helpdesk when the problem was reported to them. The ticket number will document the time and date of the problem. You **MUST** e-mail your instructor within 24 hours of the technical difficulty if you wish to request consideration.

For computer, software compatibility, or access problems call the HELP DESK phone number—352-392-HELP = 352-392-4357 (option 2).

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>

### 6.2 Semester Evaluation Process

Student assessment of instruction is an important part of efforts to improve teaching and learning.

**At approximately the mid-point of the semester**, the School of Forest Resources & Conservation will request anonymous feedback on student satisfaction on various aspects of this course. These surveys will be sent out through Canvas and are not required, but encouraged. This is not the UF Faculty Evaluation!

**At the end of the semester**, students are expected to provide UF with feedback on the quality of instruction in this course using a standard set of university and college criteria (UF Faculty Evaluations). These evaluations are conducted online at <https://evaluations.ufl.edu>. Evaluations are typically open for students to complete during the last two or three weeks of the semester; students will be notified of the

specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results>.

### 6.3 Netiquette: Communication Courtesy

All members of the class are expected to follow rules of common courtesy in all email messages, threaded discussions and chats. Failure to do so may result in loss of participation points and/or referral to the Dean of Students' Office. <http://teach.ufl.edu/docs/NetiquetteGuideforOnlineCourses.pdf>

### 6.4 Academic Honesty Policy

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: *"We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity."*

You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct or appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated.

Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see:

<http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code>.

### 6.5 Inclusive Learning Environment

This course embraces the University of Florida's Non-Discrimination Policy, which reads,

*The University shall actively promote equal opportunity policies and practices conforming to laws against discrimination. The University is committed to non-discrimination with respect to race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information and veteran status as protected under the Vietnam Era Veterans' Readjustment Assistance Act.*

If you have questions or concerns about your rights and responsibilities for inclusive learning environment, please see the instructor or refer to the Office of Multicultural & Diversity Affairs website: <http://multicultural.ufl.edu>.

### 6.6 Services for Students with Disabilities:

The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating

faculty-student disability related issues. Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation. 0001 Reid Hall, 352-392-8565, [www.dso.ufl.edu/drc/](http://www.dso.ufl.edu/drc/)

## 6.7 Software Use

All faculty, staff and students of the university are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against university policies and rules, disciplinary action will be taken as appropriate.

# 7 Campus Helping Resources

For issues with technical difficulties for e-learning in Canvas, please post your question to the Technical Help Discussion in your course, or contact the UF Help Desk at:

- [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu) | (352) 392-HELP - select option 2 | <http://elearning.ufl.edu>
- Library Help Desk support <http://cms.uflib.ufl.edu/ask>
- SFRC Academic Hub <https://ufl.instructure.com/courses/303721>

## 7.1 Student Life, Wellness, and Counseling Help

Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university's counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

- Counseling and Wellness resources <http://www.counseling.ufl.edu/cwc/>
- U Matter, We Care <http://www.umatter.ufl.edu/>
- Career Connections Center <http://career.ufl.edu/>
- Other resources are available at <http://www.distance.ufl.edu/getting-help> for online students.

## 7.2 Student Complaint Process

The School of Forest Resources & Conservation cares about your experience and we will make every effort to address course concerns. We request that all of our online students complete a course satisfaction survey each semester, which is a time for you to voice your thoughts on how your course is being delivered.

If you have a more urgent concern, your first point of contact should be the SFRC Academic Coordinator or the Graduate/Undergraduate Coordinator for the program offering the course. You may also submit a complaint directly to UF administration:

- Students in online courses: <http://www.distance.ufl.edu/student-complaint-process>
- Students in face-to-face courses: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>