References: Population Models

Books:

Intermediate-level text, emphasizing plants and hierarchical Bayesian methods.

Application of these ideas to weeds. Chap 5 describes population models.

Application of these ideas to diseases. More mathematical than the other books in this section.

Introduction to models in fisheries, many include density dependence (stock-recruitment)

Older, but a very readable review of models. pre-MCMC Bayesian methods.

All about Population Viability Analysis, i.e. incorporating various forms of stochasticity into population models.

Comprehensive summary of continuous time models. Mathematical details and lots of insight.

Application to virus populations. Currently, very active area of research. Quite readable.

Theory and examples, mostly involving differential equations for continuous time.

Huge compendium of all sorts of quantitative techniques. Source of two of the readings for this section of material.
Structured Populations:


Comprehensive treatise on all aspects of matrix models for structured populations. My lectures draw heavily from this book.


One example (the first?) of the megamatrix approach to spatial and temporal variability.


Edited volume that provides overview of all approaches (matrix, stochastic matrix, delay-differential equation, partial differential equation) for modeling structured populations.

Stochastic models:


Develops a stochastic differential equation version of the logistic model. The stationary distribution of population size is a Gamma distribution.


Estimates stochastic log lambda from different stochastic models (variants of random element, random matrix) for 5 different species. Estimate of mean depends on the model, but ranking does not.


Summarizes and compares published applications of stochastic matrix models. Many are random sequence of environments models, some are random matrix models.


Source for much of the theory of random sequence of environments models.
Computing:


Covers use of R for standard statistical methods and basic theory (likelihood, simulation).


Chapter 6 is a pretty comprehensive list of ways to generate discrete and continuous random numbers.

Estimating parameters: (Caswell’s book has an extensive section on this too).


Uses Bayesian methods to combine data from different sources. The population model is quite complex, so I find the paper hard to follow.


Bias vs. variance tradeoff in converting a continuous size measure into discrete stages.


Describes an inverse method of estimating stage-specific parameters from non-marked individuals.

Elasticity:


Empirical evaluation of how model structure influences elasticity coefficients. Has references to the early 1990’s debate on evolutionary interpretations of elasticity.


Overview article that starts a collection of articles on elasticity.


Evaluates derivatives of \( n_t \) and change in \( n_t \) to matrix parameters, where \( n_t \) is the population size at time \( t \), before convergence to asymptotic growth rate. Can be done without evaluating eigenvalues or eigenvectors, but requires matrix calculus.
Density dependence in matrix models:


Derives the derivatives of equilibrium density with respect to matrix parameters for non-linear (i.e. density dependent) matrix models


Longer, more leisurely coverage of nonlinear matrix models. Also considers the two-sex problem, which is also non-linear. If you ever wanted a short introduction to matrix differential calculus, this is a good paper to read.

Bayesian approaches:


My favorite text on Bayesian methods.


Very readable introductory treatment of hierarchical linear models, but covers a lot of ground. Includes R code. This is first place I look for practical Bayesian advice.


Intermediate level book with many useful ideas


Intro to Bayes text with good ecological examples. My favorite intro Bayes book.


Uses Bayesian methods to incorporate effects of uncertainty into simple population dynamics models.


Introductory text covering Bayesian versions of intro methods followed by 3 case studies on mark-recapture and population modeling. Has a tutorial on running WinBUGS

Describes a state-space model and parameter estimating for it using bugs. Renate and Russ have coauthored a variety of other papers applying hierarchical Bayes methods to fisheries models.


Lots of population ecology examples.


Introductory illustration of a Bayesian approach to a combining trend information and single estimates in a population monitoring problem. Part of a special feature on applications of Bayesian methods in ecology. First paper in that feature (by Ellison) is an introductory exposition of Bayesian methods, written for biologists.

Applications (a few of a very large number):


The paper underlying my loggerhead turtle story in class. Uses elasticity to evaluate different conservation options. Apparently responsible for major policy change: reducing mortality of older individuals (TED’s) instead of increasing nesting success.


One of three papers applying matrix models to weed demography in different crop rotations (corn/soybean, corn/soybean/triticale, ...). This paper compares prospective (sensitivity and elasticity) to retrospective (Life Table Response Experiment) approaches. Other two papers appeared in Weed Science.


Uses a random-matrix-elements stochastic model to evaluate consequences of environmental variability and compare management options.

Three examples of using sensitivity analysis to evaluate management strategies. Third example presents Tuljarpurkar’s method in an abbreviated but readable form and compares deterministic and stochastic estimates of elasticity.


Uses deterministic and stochastic (random environment) matrix models to evaluate population growth rates of polar bears as a function of sea ice extent. Uses LTRE’s to compare years with high and low sea ice. Last two sentences of the abstract: "The resulting stochastic population projections showed drastic declines in the polar bear population by the end of the 21st century. These projections were instrumental in the decision to list the polar bear as a threatened species under the U.S. Endangered Species Act.”


Uses density-dependent stage-structured model to assess potential impact of management strategies on an invasive plant, using demographic data collected at the invasion front.


A hierarchical model for population growth and spread, illustrated by data on the Eurasian Collared-Dove.

Concerns:


Uses long term data to assess whether population projection matrices constructed in 1978 predicted future fates of two populations. One model did; the other did not. Problems include inadequate data and lambda not representing short-term dynamics.


Example that cautions to not ignore biology. A transition matrix that ignores senescence gives misleading recommendations.


Argues for caution in translating elasticity/sensitivity into management decisions. Elasticities depend on all the elements in a matrix, so changes in one poorly estimated number can change the ranking of elasticities.
Integral Projection Models


The original integral projection model paper.


The paper that really got people interested in IPM’s. Provides “... a unified development that makes IPMs a practical alternative to deterministic matrix models for structured populations with continuous trait variation”. Gives all the math and derives a stability criterion for a model with density dependence.


Uses IPM’s and age-from-stage analysis to understand the relationship between size, age, and life expectancy in a dynamic environment.


Develops a stochastic version of the IPM.


Develops many properties of stochastic IPMs and compares them to stochastic matrix models.