**Ecological theory for the biodiversity crisis**

Preface and modelling appendices

* What is ecological modelling: statistical ecology and theoretical ecology; mechanistic versus phenomenological models. Model fitting to data (Least squares, Bayesian stats, MLE). Bootstrapping and monte-carlo. Differential equations. IBMs. Cellular Automata. Grid-based models.

**Part I. Ecology of individuals**

Chapter 1. Ecophysiology and the climate space: when to bask in the sun?

* Thermoregulation in ectotherms and endotherms. Heat exchange in an organism: radiation; convection; conduction; evaporation; and metabolism. The heat exchange equation and climate space analysis.

Chapter 2. Economic models of behavior: do animals optimize?

* Introduction to economic analysis of behavior: costs, benefits, and adaptation. Models in optimal foraging: searching predator that minimizes time and that maximizes energy; the feeding home-range of a sit-and-wait predator.

Chapter 3. Conflict resolution in ecology and evolution: war and peace

* Frequency dependent selection. Game theory and evolutionary stable strategies. Non-cooperative games: payoffs, Nash equilibrium, genetic population model. 2 player games, discrete strategies: Hawk-Dove; Prisioner's dillema.

Chapter 4. Movement and dispersal**:** should I stay or should I go

* Diffusion dispersal models as random-walk. Interactions between neighbor individuals (e.g. competition for space or resources).
* The ideal free distribution; The ideal despotic distribution.

**Part II. Ecology of populations**

Chapter 5. Demography: boom or bust

* Density independent and density dependent growth. Discrete and continuous population growth. Irregular stochastic fluctuations: demographic and environmental stochasticity. Logistic growth. Chaotic population growth. Invasions and epidemics.

Chapter 6. Demography: in the long run we are all dead

* Life history tables: survivorship and fecundity. Life expectancy at birth and female lifetime reproductive output (R0). The Euler equation. The Leslie matrix: eigenvalues and eigenvectors. Stage structure populations and graphs. Population Viability Analysis and Extinction Risk.

Chapter 7. Monitoring abundance: making it count

* Capture-recapture models. Occurrence and detection probabilities. Hierarchical occupancy models. Maximum-likelihood versus Bayesian estimation.

Chapter 8. Population harvesting: sustainability for the future

* Managing a fishery: maximum sustainable yield, constant quota and constant effort; stability and economics, production functions

Chapter 9. Populations in space: no patch is an island

* The Foley model of population viability analysis. Levin's metapopulation model: colonization extinction. Hanski metapopulation model: distance between fragments and fragment area.
* Source-sink model of Pulliam. Diffusion equation and random-walk. The Skellam reaction-diffusion model: critical patch size; invasive waves
* Road ecology.

Chapter 10. Species distribution modelling.

* SDMs as regression models.
* Habitat Suitability as affinity/empirical models.
* Mechanistic SDMs and population SDMs.

**Part III. Ecology of communities**

Chapter 11. Interactions between species

* Lotka-Volterra competion and predator-prey model: isoclines; equilibrial; stability (Jacobian); and return time.

Chapter 12. Trophic webs

* Simple models of trophic webs. Diversity versus stability. Dynamic versus topological models. Energy flow.

Chapter 13. Measuring biodiversity across scales

* Abundance; similarity; diversity indices; rarefaction curves and alpha, beta and gamma diversity. Species-abundance distributions and rank abundance. The species-are relationship.

Chapter 14: Understanding biodiversity dynamics: from islands to mainland

* Island biogeography theory: colonization versus extinction. Neutral biodiversity theory: competition for space; speciation.

Chapter 15. Modelling biodiversity change

* Using species-area relationships to model extinction rates from habitat loss. The countryside species area-relationship. Habitat amount hypothesis. Other community modelling approaches.

Chapter 16. Protecting communities in space

* Protected area design as an optimization problem. Systematic conservation planning. Minimum set method and maximum coverage method. Connectivity analysis. Rewilding.

**Part IV. Ecology of ecosystems**

Chapter 17. Biodiversity and ecosystem function

* Modelling the biosphere: DGVMs and scenario modelling.

Chapter 18. Modelling ecosystem services and scenarios

* Modelling supply versus demand of ecosystem services; INVEST models

Chapter 19. Linking economic models with biodiversity models

* Multi-regional input-output models of the economy. Consumption versus production impacts. Biodiversity foot print of nations.

Chapter 20. Social-ecological models.

* Social-ecological models: multiple stable states; regime shifts and tipping points; histeresis.