The definition of a population

- If given the description of a study you should be able to discuss whether the individuals comprising the study likely represent a population or not.
- You should be able to give an example of a population
- You should be able to define a population
- Why is it important that populations are defined correctly?

Evolutionary Ecology

- Know that historically, population genetics has made strong assumptions about weak effects of genes and separation of time scales (evolution is slow, ecology is fast), but that contemporary ecoevolutionay dynamics and ideas of rapid evolution challenges these assumptions, arguing strong feedbacks between ecology and evolution.

Estimating population size

- You should be able to estimate population size given sample counts under simple random sampling (formula provided)
- You should be able to estimate a 95% confidence interval given counts under simple random sampling.

Discrete time geometric growth (referred to as exponential growth in Vandermeer and Gordon)

- You should be able to calculate λ given values of b and d.
- You should know for what values of λ the population will increase.
- Be able to calculate the population at any time in the future for a discrete time geometric model.
- Be able to calculate the time at which the population will reach a given size.
- Know which formula to use for which questions.
- Answer questions similar to those on the assignment.
- Give an example of a population that would grow exponentially (made up is ok).
- Know that geometric growth produces unbounded population growth and has no density dependence.

Protection Island

- Be able to calculate b, d and λ from reported facts just like we did for the Protection Island pheasant population.
- Remember that b is the per capita number of births that survive the time step. Remember that d is the fraction of the population at the start of the time step that does not survive to the next time step.
- Be able to acknowledge assumptions that you've made for calculations for b and d, for example, b doesn't change over time, all hatchlings survive the time step, etc.

Exponential growth in continuous time.

- Be able to determine when the population will increase or decrease.
- Know how to calculate r given values of b and d.
- Know the maximum value of d and how this compares with a discrete time geometric.
- Be able to calculate the population size at any time in the future.
- Be able to explain why the continuous time exponential predicts faster population growth or decline than discrete time geometric growth when λ=r.
- Know when a continuous time model is more appropriate than a discrete time model.
- Give an example of a population that is growing exponentially.

Continuous time logistic growth and density dependence

- Why does exponential growth not apply to many populations in general?
- Draw a sketch of how the per capita net reproductive rate changes with N.
- Know the meaning of r in the logistic equation and in the exponential equation is different. Explain the difference.
- Solve for the equilibria of the logistic equation.
- Exercise 1.9 from p12 of the textbook. The intrinsic rate of increase (or decrease) can be calculated as $(N_{t+1} – N_t)/\Delta t$. For example, when t = 1964, Δt = 1965-1964 = 1. You will need to calculate N_{1965}-N_{1964}. Then you want to record N_{1964} for the x-axis. Then you need to proceed to t = 1965, etc.
- What does it mean for a population to be in equilibrium?
- Exercise 1.13 from the textbook on p17.

Equilibrium stability in continuous time and logistic growth

- What does it mean if a population is stable or unstable.
- Be able to make line-arrow diagrams to assess equilibrium stability
- Give an example of a population growth model with an unstable equilibrium.
- Know the conditions for the logistic equation to predict increasing or decreasing growth.
- Give an example of a model that has density dependence.
- Give an example of a model that has no density dependence.

Discrete time models of density dependence

- Know the definition of an equilibrium for a discrete time model.
- Be able to find an equilibrium of a discrete time population growth model with density dependence
- Know how to verify a point is an equilibrium
- Know what type of dynamics every model we have covered has.
- Be able to sketch population size (y-axis) vs. time (x-axis) for the population models we studied in class, i.e. could give convergence to a carrying capacity, cycles or chaos.
- Know weakness of May's logistic growth model.
- Be able to read the bifurcation diagram for May's logistic (i.e. lambda is on the x-axis, stable states are on the y-axis)
- Be able to graph the per capita growth rate versus population size for all of the discrete time models of density dependence

Overcompensation and complex dynamics

- Know what overcompensation is.
- Know which models we have studied that have overcompensation leading to periodic cycles and chaos

Evolution in populations with no density dependence

- Know the outcome of evolutionary dynamics when there is no density dependence in the population dynamics
- Be able to calculate the equilibria and determine the stability using a line-arrow diagram for $dp/dt = sp(1-p)$.

Evolution in populations experiencing density dependence

- Name the conditions outlined in Pianka 1970, that may select for many (r-select) or high quality (K-selected) offspring.
- Recognize that in absence of a trade-off, then the production of many high quality offspring would occur.
- In a graph, of the per capita growth rate $(1/N)(dN/dt)$ versus N, for a continuous time logistic growth model, recognize what aspect of the graph would correspond to the strength of density dependence.
- Understand what parameter a logistic growth model would correspond to the strength of density dependence.
- Understand that for an evolutionary problem it is necessary to decide which trait there is genetic variation in. It is also necessary to evaluate whether it is biologically plausible that there could be variation in this trait, i.e. can individuals evolve carrying capacity, or is that a characteristic of the environment.
- Know that complex evolutionary dynamics (i.e., no one trait that is uninvasible) may when population dynamics are density-dependent.
- Know that a key aspect of modeling evolution in populations with density-dependent population dynamics is to define how the genotypes affect each other, i.e. Travis et al., they system of equations (2).

Age/Stage structure

- Given a discrete time model be able to write the projection matrix
- Given a projection matrix, be able to draw a picture showing the possible transitions between the stage class (and visa versa)
- Know what the different elements of the projection matrix mean
- Know what the right eigenvector tells us.
- Know that to interpret the right eigenvector sensibility you need to normalize it so that the sum of the elements are 1.

- Given a projection matrix, be able to predict the population size of each stage in the future (by multiplying the matrix by the vector on the right)
- Know the type of dynamics of an age/stage structured matrix population model
- Know if the matrix population models we studied have density dependence or not.
- Know the general form a Leslie matrix. Which elements can be > 1.
- Be able to calculate the eigenvalues for a 2 by 2 matrix.
- Know what needs to be true of the eigenvalues in order for the population to be growing (i.e., the zero equilibrium is unstable).
- Know when to use a stage or age-structured formulation

Spatial models in population biology

- Know what the terms in the Levins metapopulation model represent
- Know what the variable, p, is.
- Know what the difference in assumptions are that leads to the rescue effect formulation and the propagule rain form.
- Know the equilibria for the each of the metapopulation models and their conditions for stability.
- Know the meaning of the parameters m and e.

Reaction-diffusion models

- Know the assumption concerning dispersal for a reaction-diffusion model
- Know the qualitative properties for the spread rate
- Know the assumptions of the reaction-diffusion formulation (particularly pertaining to dispersal)
- Be able to explain the conclusions of the validation-parameterization exercise are for the muskrat, sea otter, cereal leaf beetle and cabbage white butterfly examples.

Climate change

- Why are all the models we have studies previously inappropriate to predict how species will respond to climate change?
- Is the relationship between temperature and fitness necessarily symmetric?
- Be able to explain what Figures 1 and 2 of Chen et al. 2011. show.
- Given the model discussed in Leroux et al. what types of life history characteristics are associated with species that would be expected to keep pace with their shifting climate envelope/thermal tolerance limits?
- Explain how the results of Sunday et al. might explain why terrestrial ectotherms have not gone extinct near the equator in spite of climate warming?
- Give an example of different limiting factors at the poleward (or upward) extent of a population versus the equatorial (or downward) extent of a population.

Evolutionary ecology

- What are eco-evolutionary dynamics?
- Give an example of how ecology affects evolution
- Given an example of how evolution affects ecology

Life history evolution

- Understand that trade-offs are the reason why age of maturity, body size, fecundity and/or survivorship are intermediate valued.
- Be able to work with the Lotka-Euler equation to calculate the phenotype with the highest fitness for trade-offs between age of first reproduction, survivorship, and or fecundity.
- Given a table of life history data for two different phenotypes, be able to describe the type of trade-off shown.

Game theory

- Know the game theory problems are when fitness depends not only on the focal individual's phenotype, but also the phenotype of the individual's that they interact with.
- Be able to apply the definitions of an Evolutionarily Stable Strategy (ESS) and a Nash equilibrium (NE) to a payoff matrix.

- Know that an ESS cannot be invaded by a rare mutant with another strategy/phenotype, given that the majority of individual's have inherited the ESS.
- Know that the Nash equilibrium strategy means that given that the majority have adopted the NE strategy there is no incentive to change.
- Know the relationship between a NE and an ESS.

Evolutionary invasion analysis/Adaptive dynamics

- Be able to read a pairwise invisibility plot to find the evolutionarily stable strategy and know if this strategy is convergence stable.
- Know that the playoffs for the game theory problem can be derived from the ecology/population dynamics.