UNIT Extra notes

1 Introduction

Competition

- Competition occurs when two species both depend on the same resource, or resources
- Each species' ability to reproduce successfully is reduced by the presence of the other
- Via effects on any component of successful reproduction:
  - **Answer:** Survival, growth, producing offspring
- Species may be very similar, or very different
  - **Answer:** Oaks and maples competing for light
  - **Answer:** Ants and mammals competing for leaves
  - **Answer:** Mussels and algae competing for space in the intertidal zone

Competition in ecology

- What factors determine which species survive in which habitats?
- What factors determine how many similar species can co-exist?
- Why do similar species coexist at all?

Flour beetles

- There is a series of experiments where researchers allow two species of flour beetles to compete in different laboratory environments
- The larger species survives better in drier conditions, and the smaller species reproduces faster in moister conditions
- Poll: What outcomes do you expect under wet vs dry conditions?
  - **Answer:** Each species wins when conditions are better for it
- Poll: What if I "tune" the conditions to something in between?
  - **Answer:** The species could both survive together
  - **Answer:** Sometimes one survives, and sometimes the other
    - **Answer:** Whichever species got a "head start" would survive

Outcomes of competition

- In a given stable environment, we generally expect the competitive interaction between two species to have one of the following results
  - **Dominance**: one species wins every time
  - **Co-existence**: if both species are present, they will both persist
  - **Founder control**: whichever species gets established first will exclude the other

2 Population model with competition

- We modeled a single species using the equation:
  - $\frac{dN}{dt} = (b(N) - d(N))N$
- We want to modify this for a species which is competing with another species
  - $\frac{dN_1}{dt} = ?$
- The amount of competition seen by species 1 is $\tilde{N}_1 = N_1 + \alpha_{21} N_2$
- How should our equation change?
  - **Answer:** $\frac{dN_1}{dt} = (b_1(\tilde{N}_1) - d_1(\tilde{N}_1))N_1$
  - **Answer:** $\frac{dN_2}{dt} = (b_2(\tilde{N}_2) - d_2(\tilde{N}_2))N_2$

Carrying capacity

- For this unit, we will mostly ignore Allee effects
- Therefore, we expect each species to converge to its *carrying capacity* K (or K_1 and K_2) when it is alone
- How do we define carrying capacity in this system?
  - **Answer:** The birth rate equals the death rate: $b(K) = d(K)$

Carrying capacity with competition

- $\frac{dN_1}{dt} = (b_1(\tilde{N}_1) - d_1(\tilde{N}_1))N_1$
- How can this population be at equilibrium?
  - **Answer:** $\tilde{N}_1 = K_1$: the species has the right amount of competitive pressure to make $\mathcal{R} = 1$
  - **Answer:** $N_1 = 0$: the species is not present

Logistic model

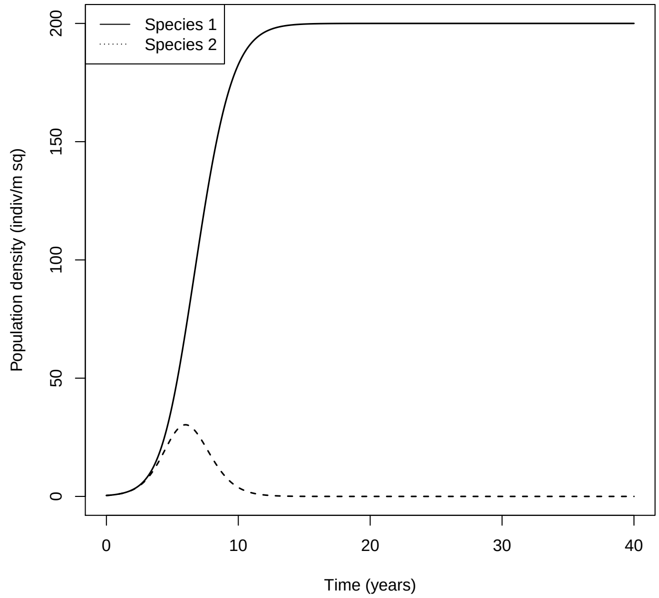
- You've probably learned about the logistic model, if not you may learn about it later
- This model is similar to the logistic model, except:
  - Birth and death are tracked separately
  - We don't assume functions are straight lines
- Everything we say about this model also applies to the logistic model

2.1 Balanced competition

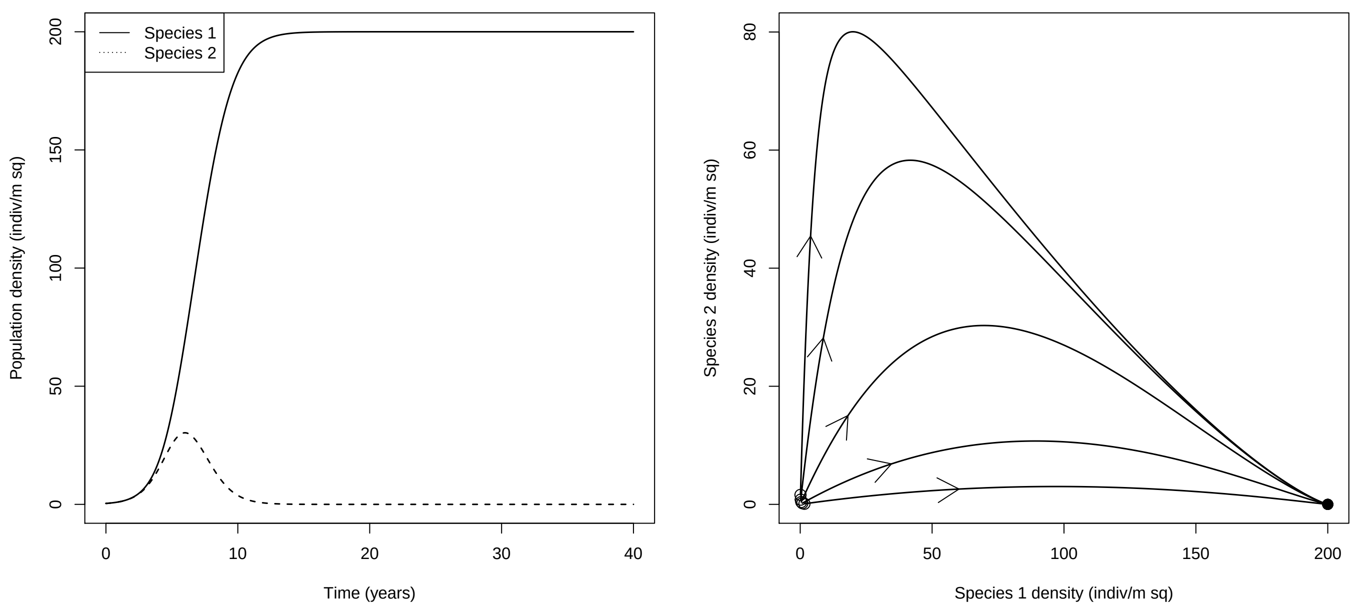
Equal competition

- If the αs are both equal to one, we have equal competition. This means that the competitive effect of an individual from either species is the same.
- If $\bar{N} = N_1 + N_2$, then:
  - $\dfrac{dN_1}{dt} = (b_1(\bar{N}) - d_1(\bar{N}))N_1$
  - $\dfrac{dN_2}{dt} = (b_2(\bar{N}) - d_2(\bar{N}))N_2$
- What happens in this case?
  - **Answer:** Competition is mediated by only one quantity, $\bar{N}$.
  - **Answer:** Whichever species has a higher value of K can survive at a density where the other one can't
  - **Answer:** Dominance!

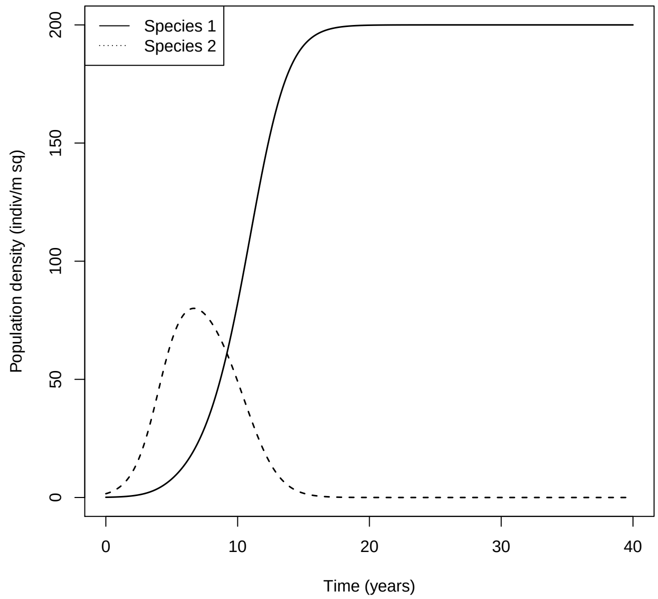
Comment slide: *Dominance time plot*

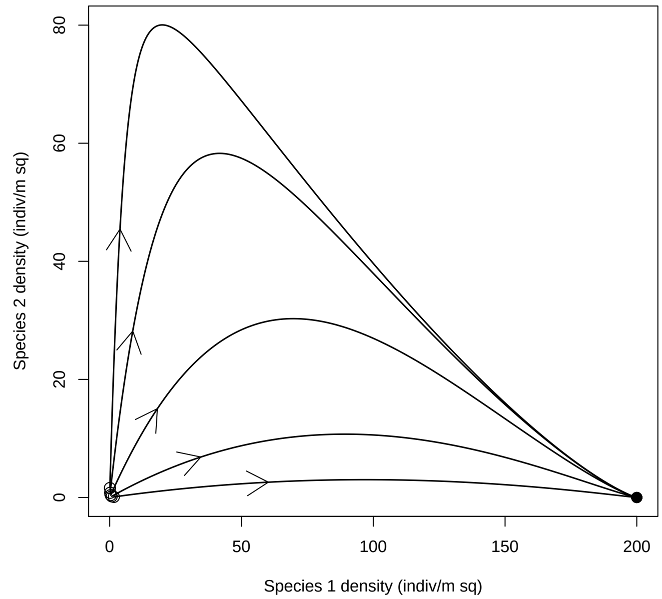


Dominance



<u>Comment slide</u>: *Dominance*





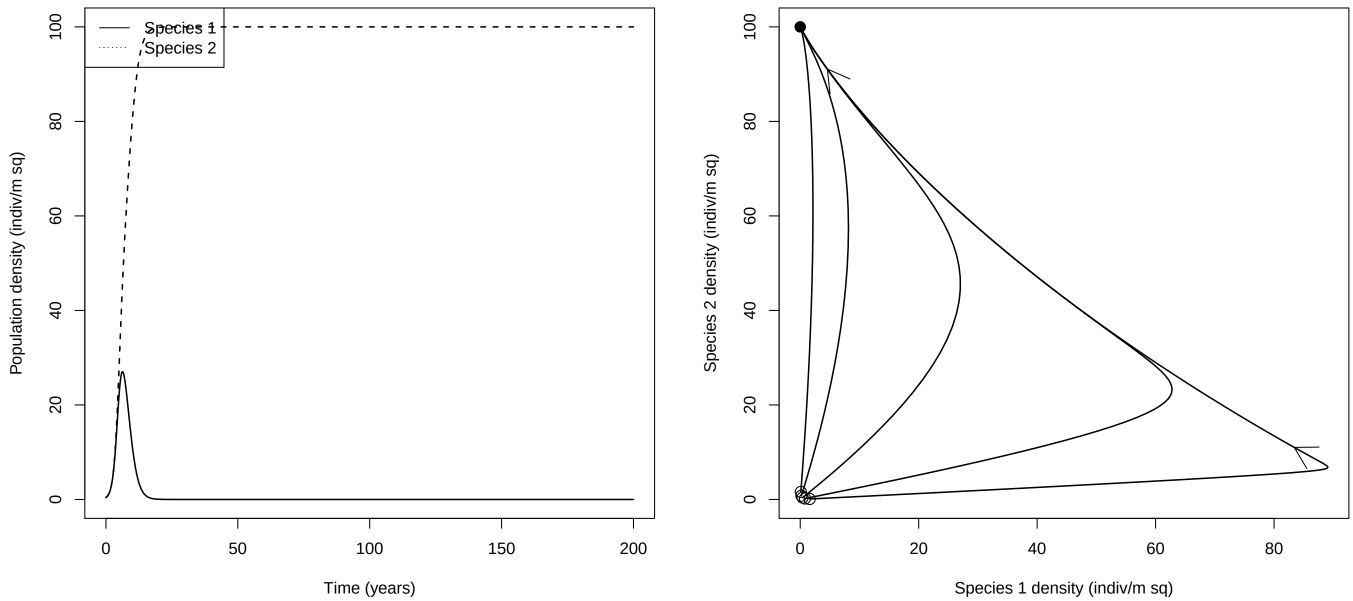
Time plots and phase plots

- *Time plots* have time on one axis and show population quantities on another
  - Fixed parameters (usually)
  - Single starting points
- *Phase plots* have population quantities on both axes
  - Fixed parameters (usually)
  - Multiple starting points (usually)
  - Better for seeing overall pattern of results
  - Worse for seeing rates (how quickly things change)

Reading phase plots

- Log or linear (per capita vs. total perspective)
- Open circles are starting points
- Closed circles are ending points
- Arrows show direction of time

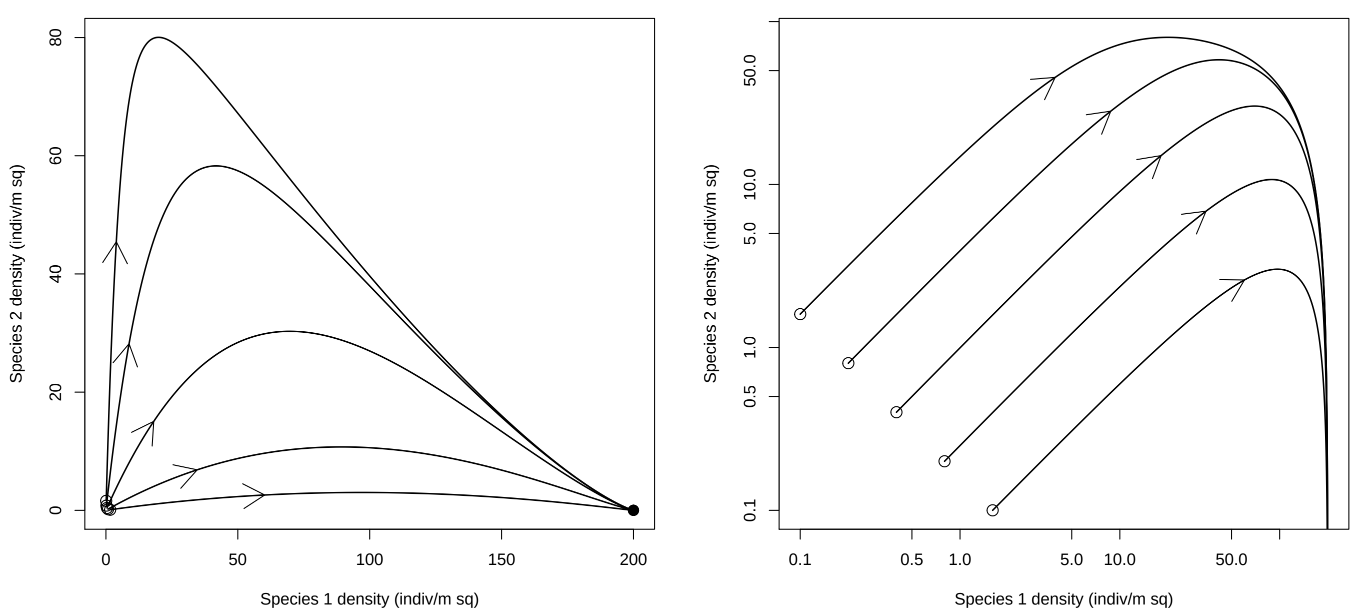
Dominance again



Log plots and linear plots

- We will look at *population* quantities on either a *log* or *linear* scale
- Log plots show *proportional* differences
- Linear plots show *absolute* differences

Different scales



Units of α

- $\tilde{N}_1 = N_1 + \alpha_{21} N_2$; $\tilde{N}_2 = N_2 + \alpha_{12} N_1$
- α_{21} measures the strength of the competitive effect *of* individuals of species 2 *on* the growth rate of species 1.
- What are the units of α_{21}?
  - **Answer:** $\mathrm{indiv}_1/\,\mathrm{indiv}_2$
- Since α has units, we don't expect there to be anything special about $\alpha = 1$
- Equal competition (both species have the same effect on each other) is a special case of balanced competition (both species have the same *relative* effect on each other)

Balanced competition example

- Two plants compete with each other for water. The value of α_{21} is $4\,\mathrm{indiv}_1/\,\mathrm{indiv}_2$
- Poll: Which species is bigger?
  - **Answer:** $4 indiv_1$ have as much impact as $indiv_2$
  - **Answer:** Species 2 individuals are bigger
- If they're only competing for water, what's the value of α_{12}?
  - **Answer:** $\alpha_{12} = 1\,\mathrm{indiv}_2/4\,\mathrm{indiv}_1$
  - **Answer:** $1 indiv_2$ has as much impact as $4 indiv_1$

Balanced competition

- Poll: What results do we expect from balanced competition?
  - **Answer:** Balanced competition works just like equal competition
  - **Answer:** Both species experience total density in the same way
  - **Answer:** So the species with the higher carrying capacity (compared using the same units) will dominate
  - **Answer:** This is not necessarily the bigger species
- If competition is balanced, there is no tendency for founder control or for coexistence

Measuring competitive effects

- It makes sense that we have a range of parameters that give us balanced competition, because we know qualitative changes in dynamics are explained by unitless parameters
- What's the unitless parameter here?
  - **Answer:** $C = \alpha_{21}\alpha_{12}$
- C measures the relative effect of between-species and within-species competition
  - $C = 1$ means competition is balanced
  - $C < 1$ means there is more competition within species (tendency for coexistence)
  - $C > 1$ means there is more competition between species (tendency for founder control)