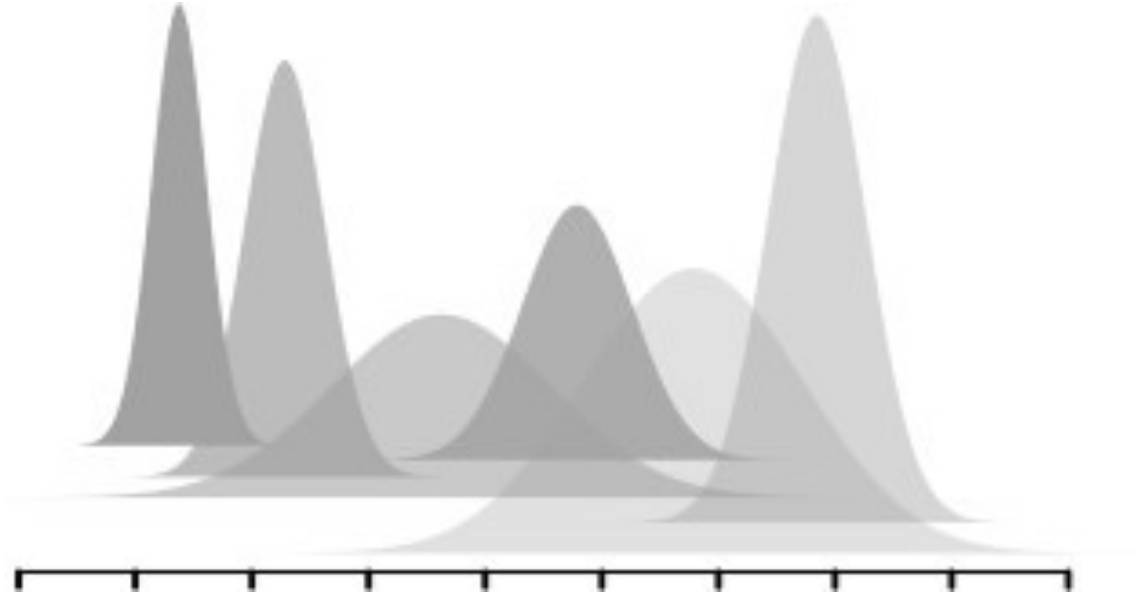
4.1 How To Use Ecological Models



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What is theory?

An explanation of an ecological phenomenon, that explains how an ecological process works or why an ecological pattern is observed

An idea becomes scientifically useful when expressed as a testable *theory*, often in the form of a *mathematical model*

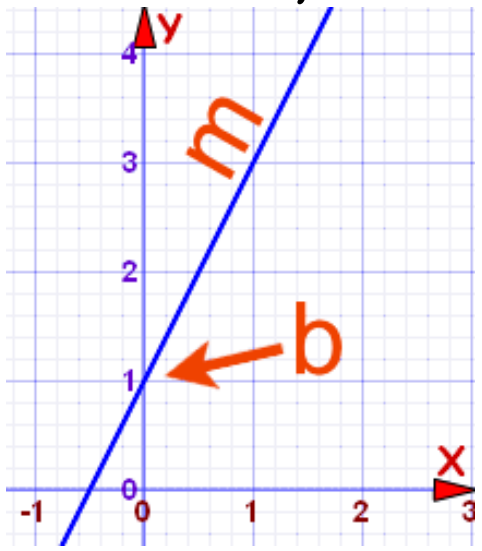
A *mathematical model* is an equation or a set of equations that describes how different aspects of a system relate to one another

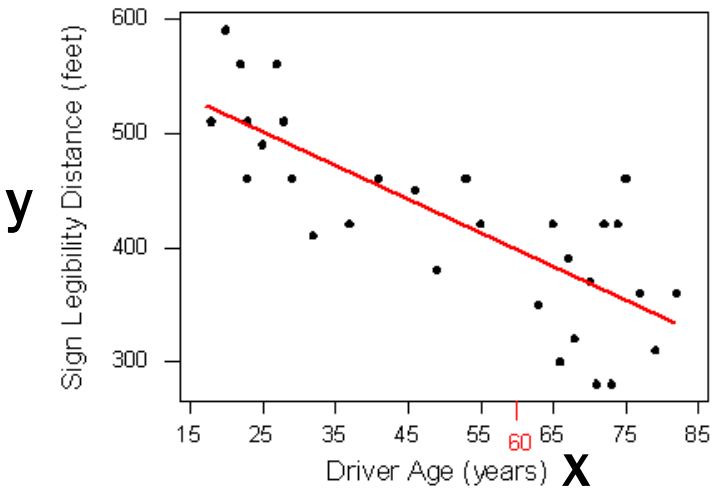
Example 1. Formula for a line → Linear model

$$y = mx + b$$

m - slope

b - y-intercept (where line crosses y-axis.... value of y when x=0)





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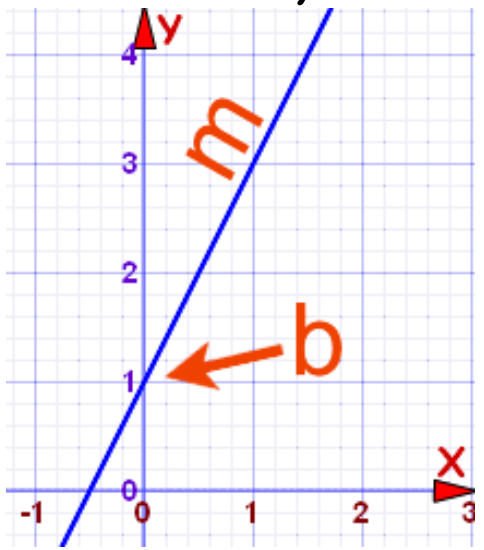
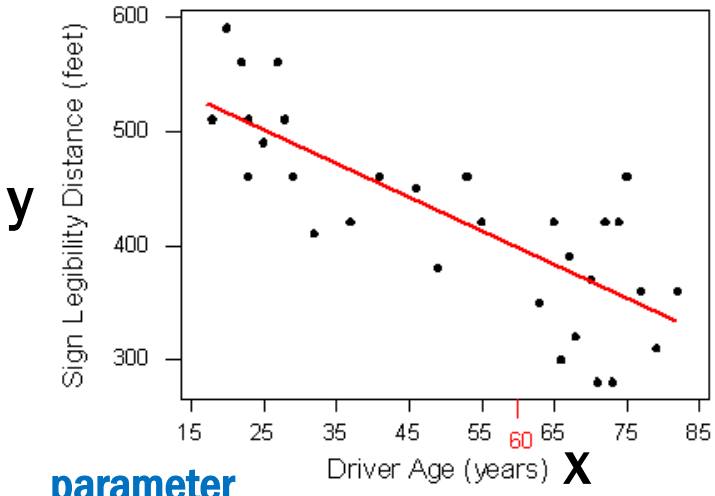


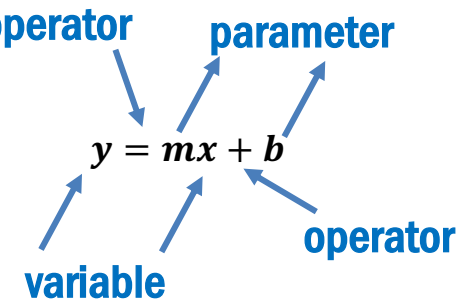


Each symbol in an equation can be classified as a *variable*, a *parameter*, or an *operator*.

variable - a quantity whose value changes either dependently or independently of other variables

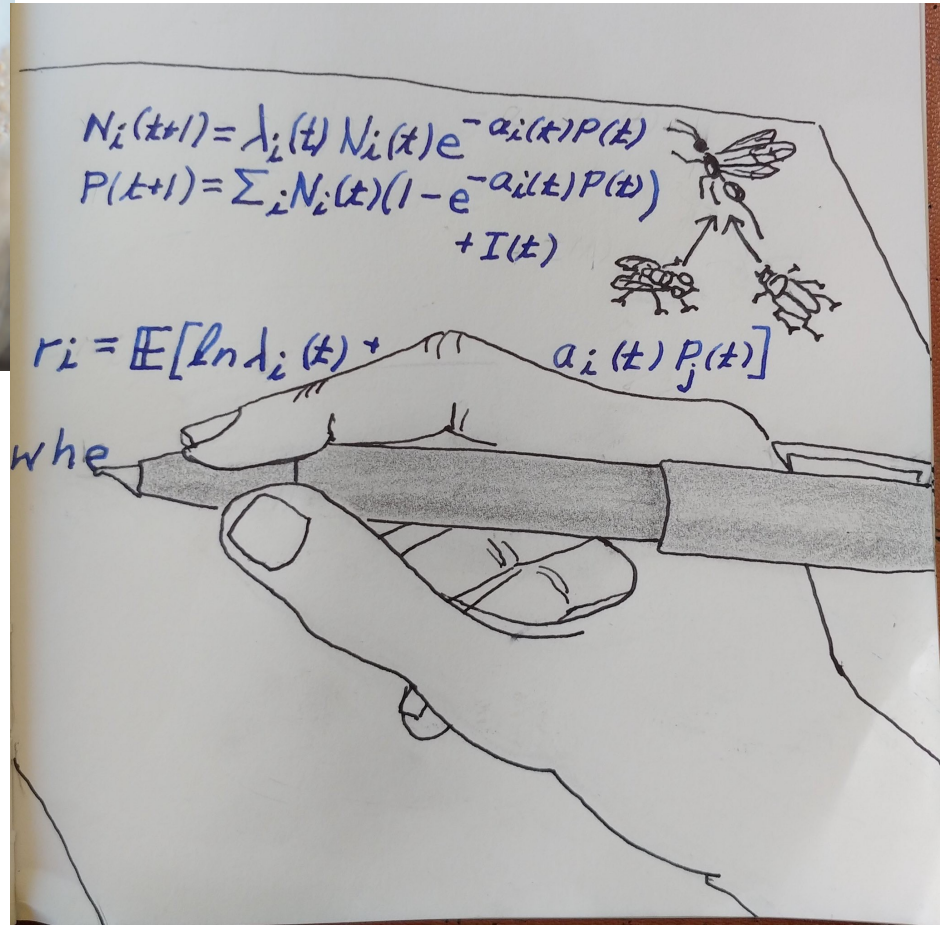
parameter - fixed quantities that remain constant within a given equation

operator - describes how different quantities in equations interact with each other, including simple operations from algebra (addition, multiplication, etc.) and complex ones (set theory ∩, calculus ∫)



Why use theory?

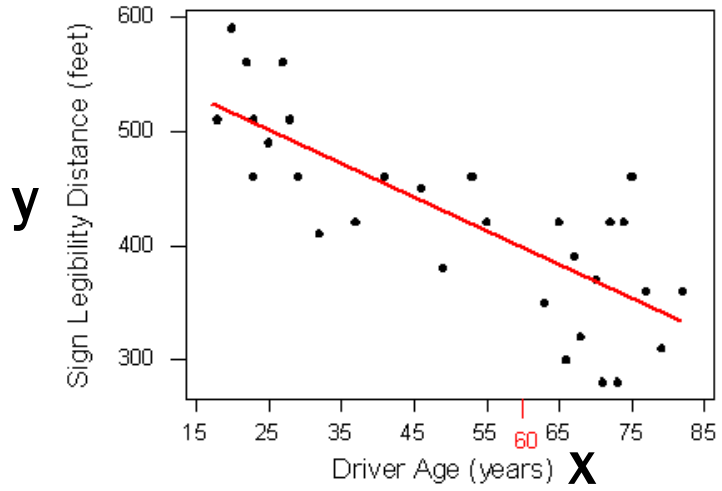
"A model is a representation of a particular thing, idea, or condition"



Why use theory?

A *mathematical model* is an equation or a set of equations that describes how different aspects of a system relate to one another

"theory provides a framework to guide inquiry, experimental design, and the interpretation of observed patterns, supplies mathematical tools to harness information from collected data, and connects individual experiments to general ideas about how nature operates"



Example 1. Formula for a line → Linear model

$$y = mx + b$$

b = 525

m = -1.77

if x = 60, y = 433

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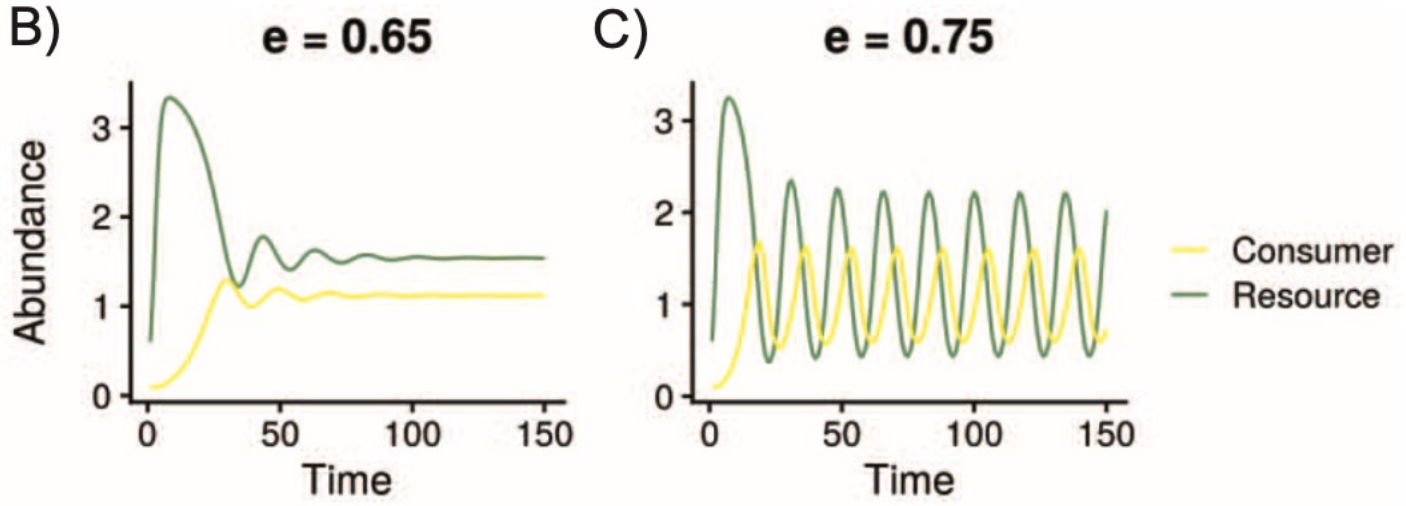
How to understand a mathematical model?

$$\frac{dR}{dt} = rR\left(1 - \frac{R}{K}\right) - \frac{aR}{1 + ahR}C$$

$$\frac{dC}{dt} = e\frac{aR}{1 + ahR}C - mC$$



variables – R, C

parameters – r, K, a, h, e, m

operators – =, -, ÷, ×

"Rosenzweig-MacArthur consumer-resource model where both the consumer (with density represented by the variable C) and the resource (with density R) grow and impact each other (Rosenzweig and MacArthur 1963)"

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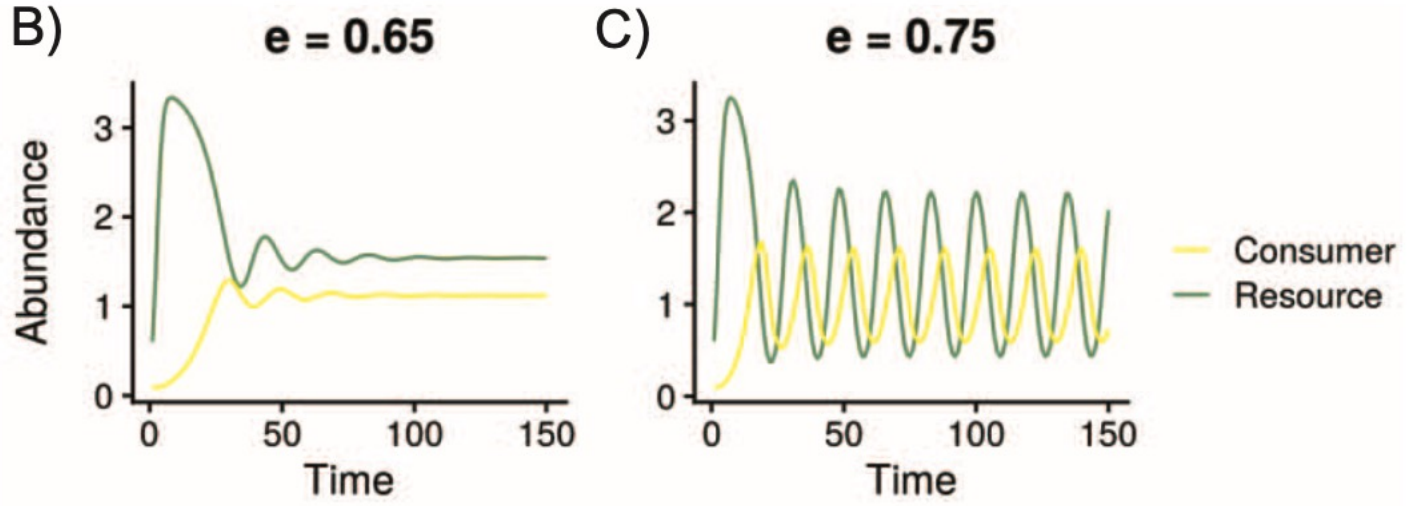

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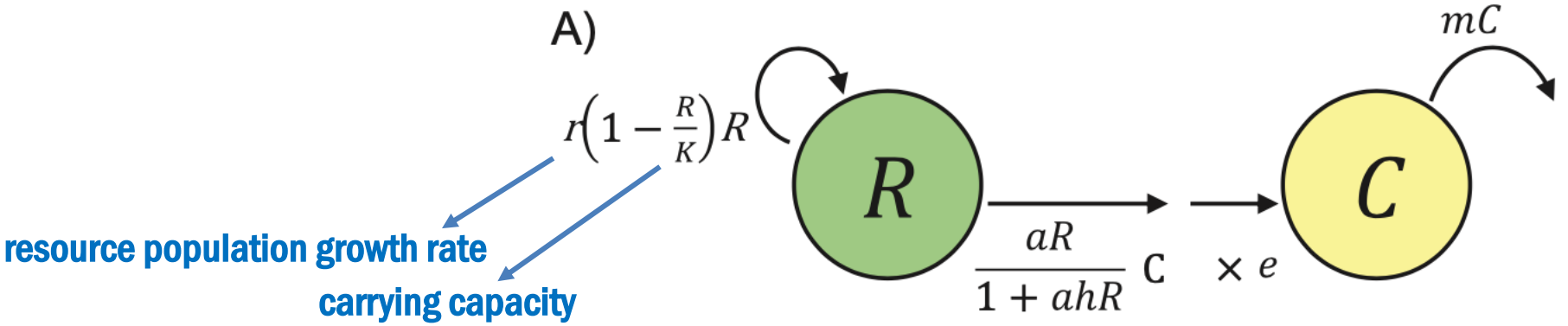
consumer death rate



resource population growth rate

carrying capacity

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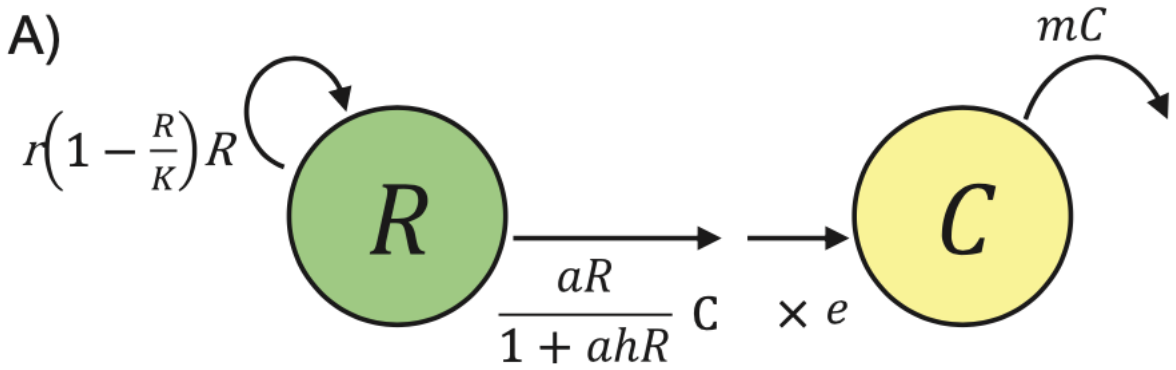
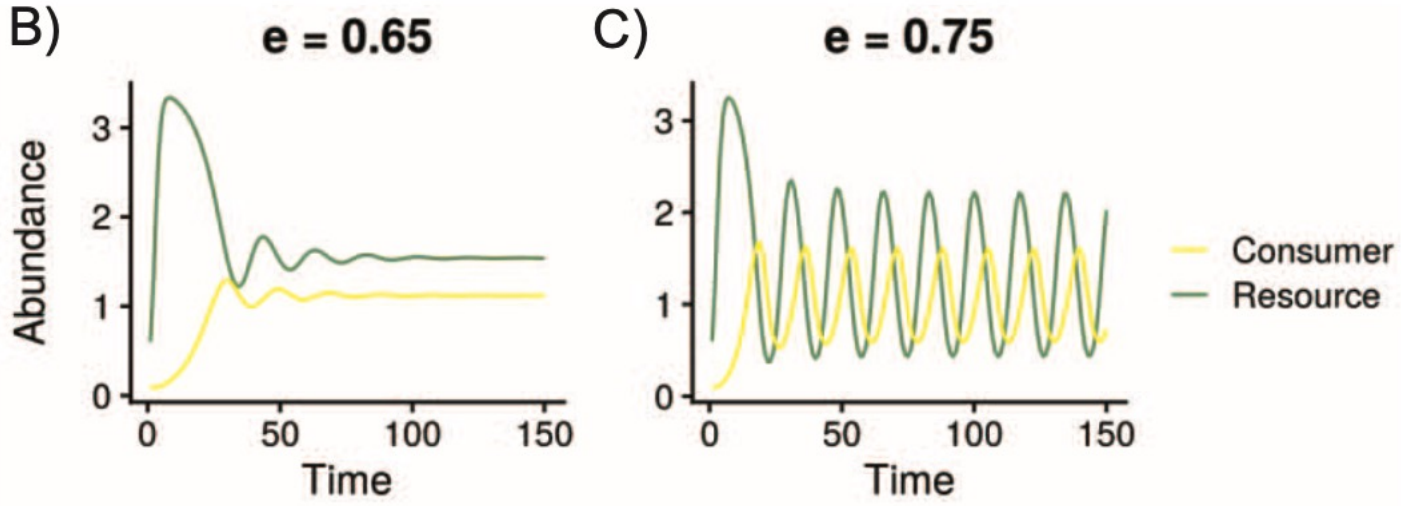




parameter	
r	population growth rate
K	carrying capacity
m	death rate
a	clearance rate (the area or volume cleared of prey per predator per prey unit time)
h	handling rate (the amount of time a consumer spends handling each prey item (e.g., time to kill, eat, digest, etc.) that would otherwise be spent searching for prey)
e	the conversion rate of consumed resources into new consumer individuals

How to understand a mathematical model?

1: Align the Math with the Biology

2: Think in Terms of Stocks and Flows

3: Verbally summarize complex terms

$$e\frac{aR}{1+ahR}C$$

consumer birth rate

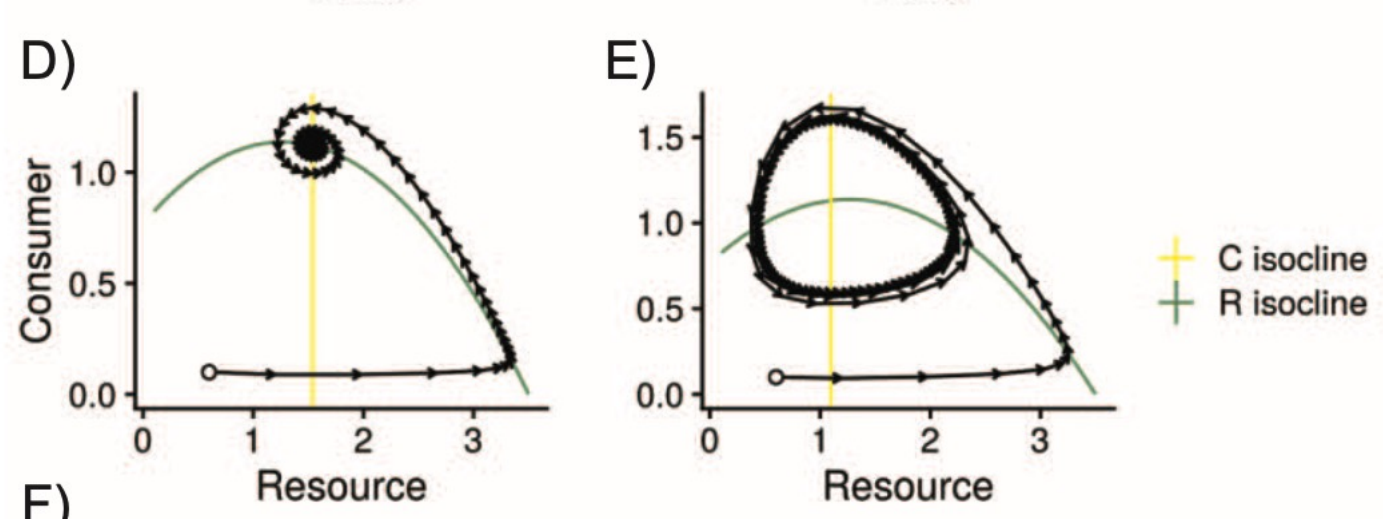
foraging rate per consumer

number of consumers

number of consumers produced per resource eaten

4: Achieve a Working Understanding of Equations

5: Visualize Functions Precisely by Plotting Them



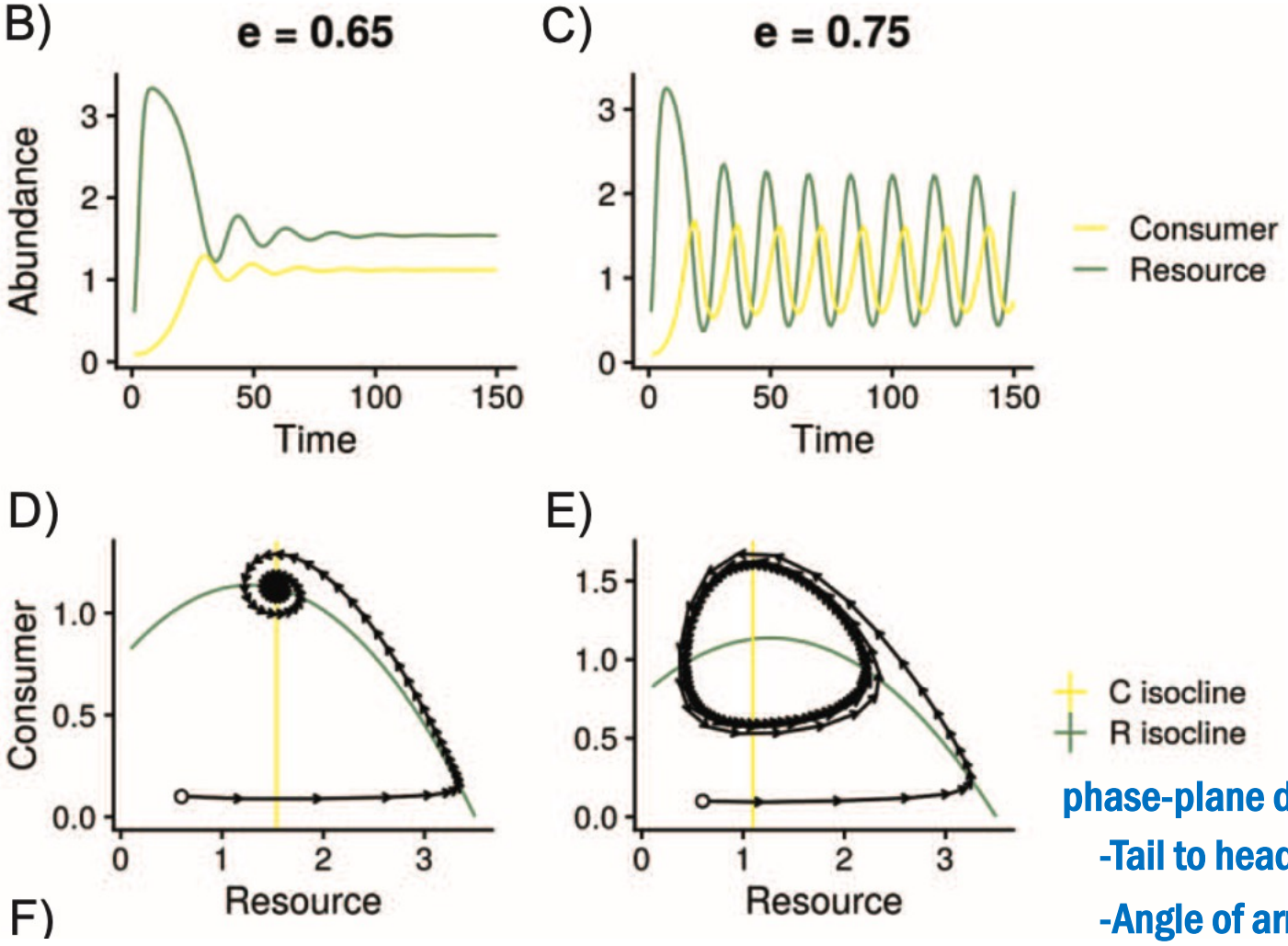
phase-plane diagram – summarize the trajectories of variables

-Tail to head of arrow show change from beginning to end of time step

-Angle of arrow shows relative magnitude of change (→ much more change in resource than in consumer)

-Isocline: solid line. For C, it is the R value where C has no net growth. Intersection of line is 2-species equilibrium (where values no longer change)

How to understand a mathematical model?



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An Empiricist's Guide to Using Ecological Theory

1) What are some reasons that ecologists may not use theoretical models and predictions in their research? What is the value of using theory?

2) On page 9 (the bottom right) the authors discuss using equations, and fitting data to models - how did we see that in action during the ecotoxicology lecture last week?

3) 5) Describe the "plug and play" approach to understanding a model (Tip 4,5) - have you done this yet with a model?

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