# **Ecology**

Populations

Communities

Ecosystems

# Population Ecology

How do populations grow?

Most widely used branch of ecology
- •Endangered species
- •Invasive species
- •Agricultural Pests
- •Disease dynamics

# Major Problem: People vs. Elephants

- Park is too small for the elephants.
- People are settling outside the park
- Elephants like farm food
- Elephants and cows both need water

Task: Make a model of elephant population dynamics to ask "what-if" questions about purchasing more land.

w/ Sandy Andelman
Data from (2001) Moss, CJ. J Zool. 255: 145-156

# How will the elephant population grow?

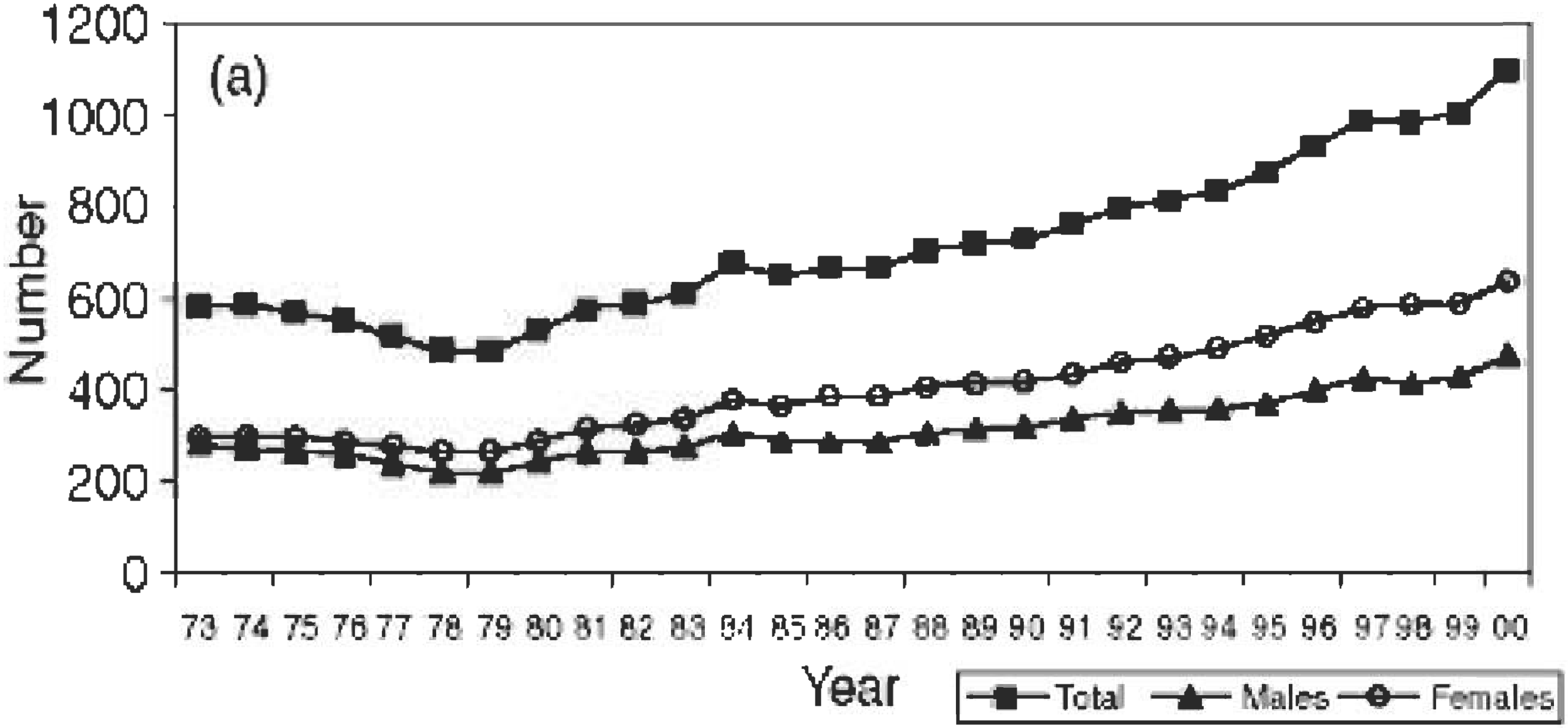
$$dN/dt = B - D + I - E$$

B = Births

D = Deaths

I = Immigration

E = Emigration



(a)
Number
1200
1000
800
600
400
200
0
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00
Year
Total
Males
Females

# Continuous Exponential Growth

Births = $bN_t$

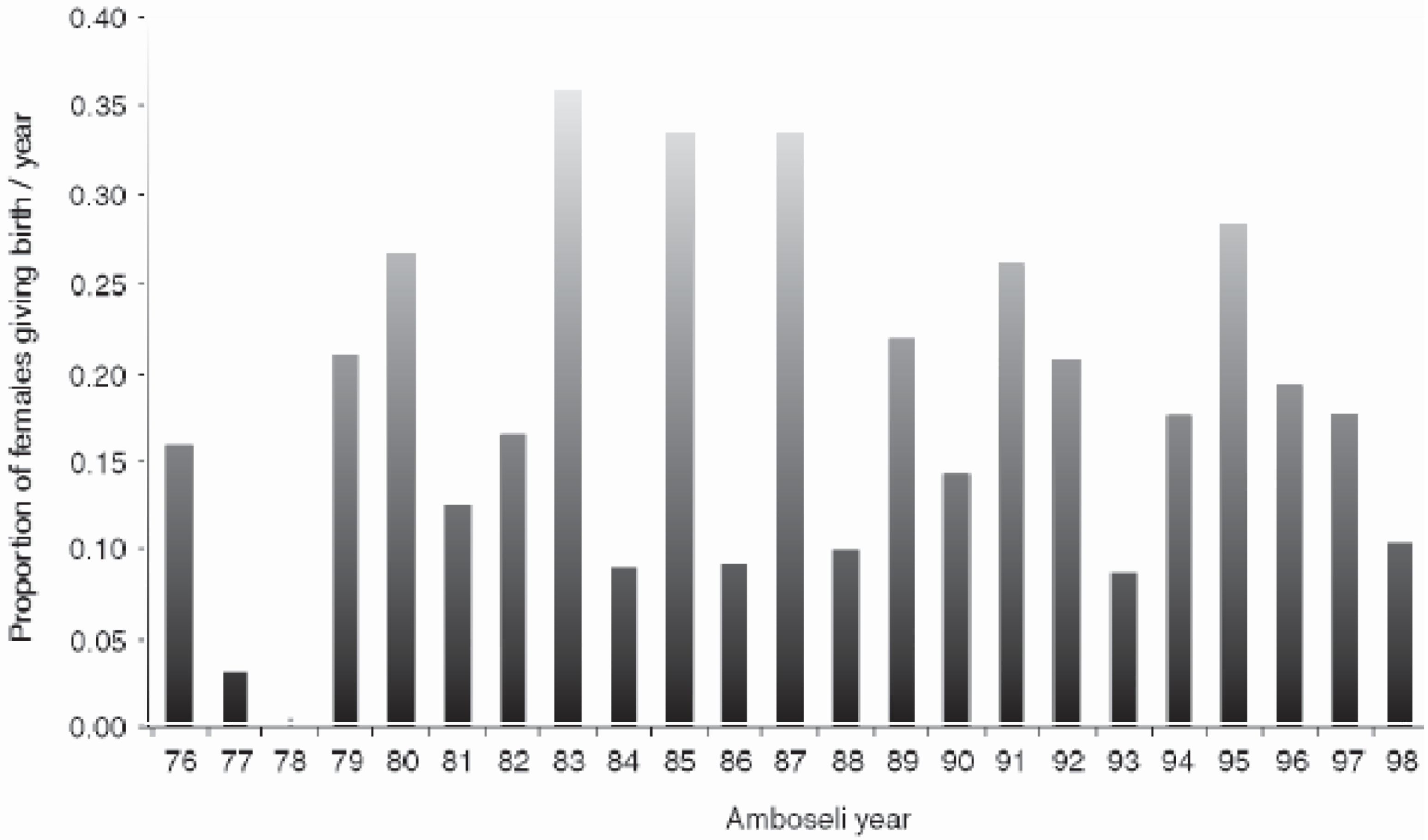
Deaths = $dN_t$

Ignore I and E for now

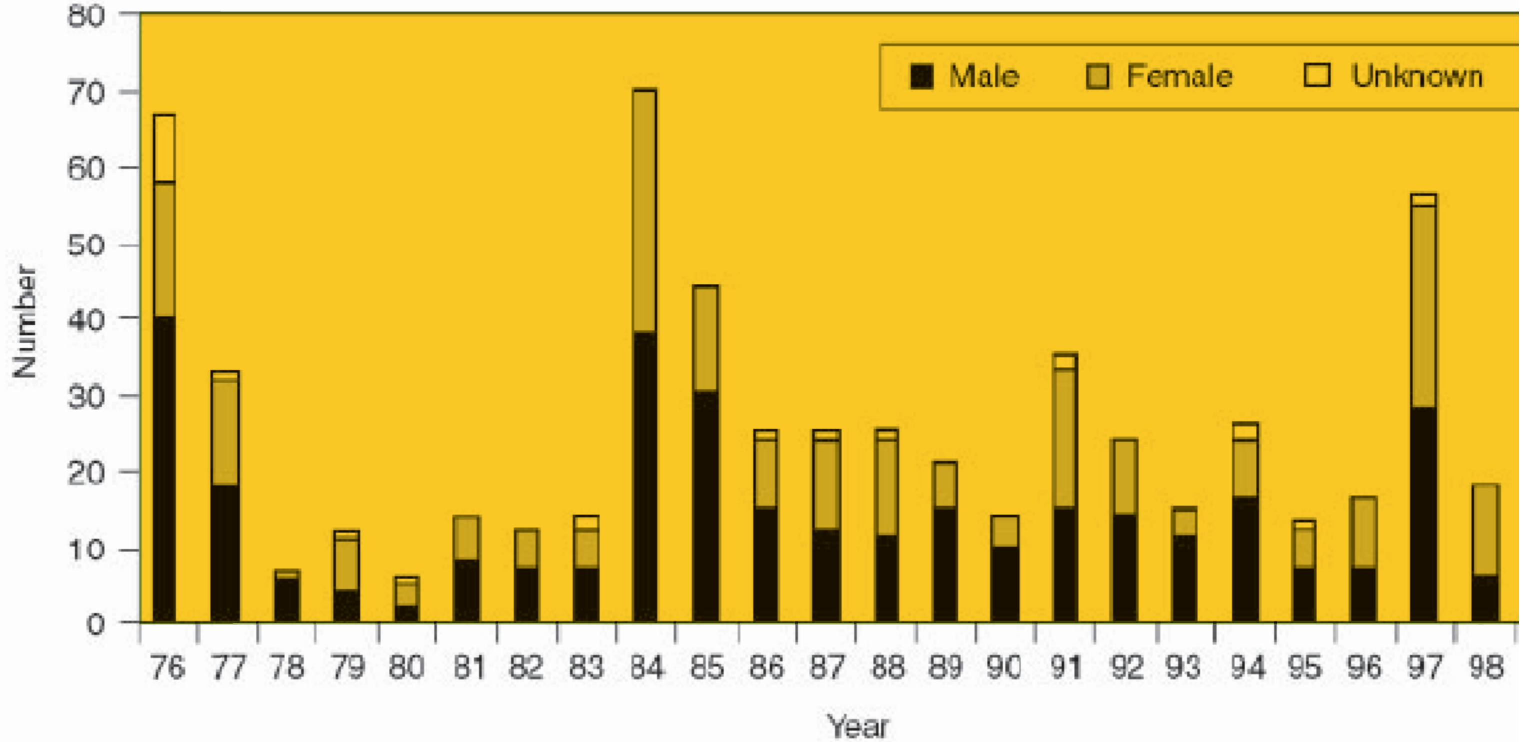
$$\frac{dN}{dt} = bN_t - dN_t = (b - d) N_t = r N_t$$

Integrate to get Nt =

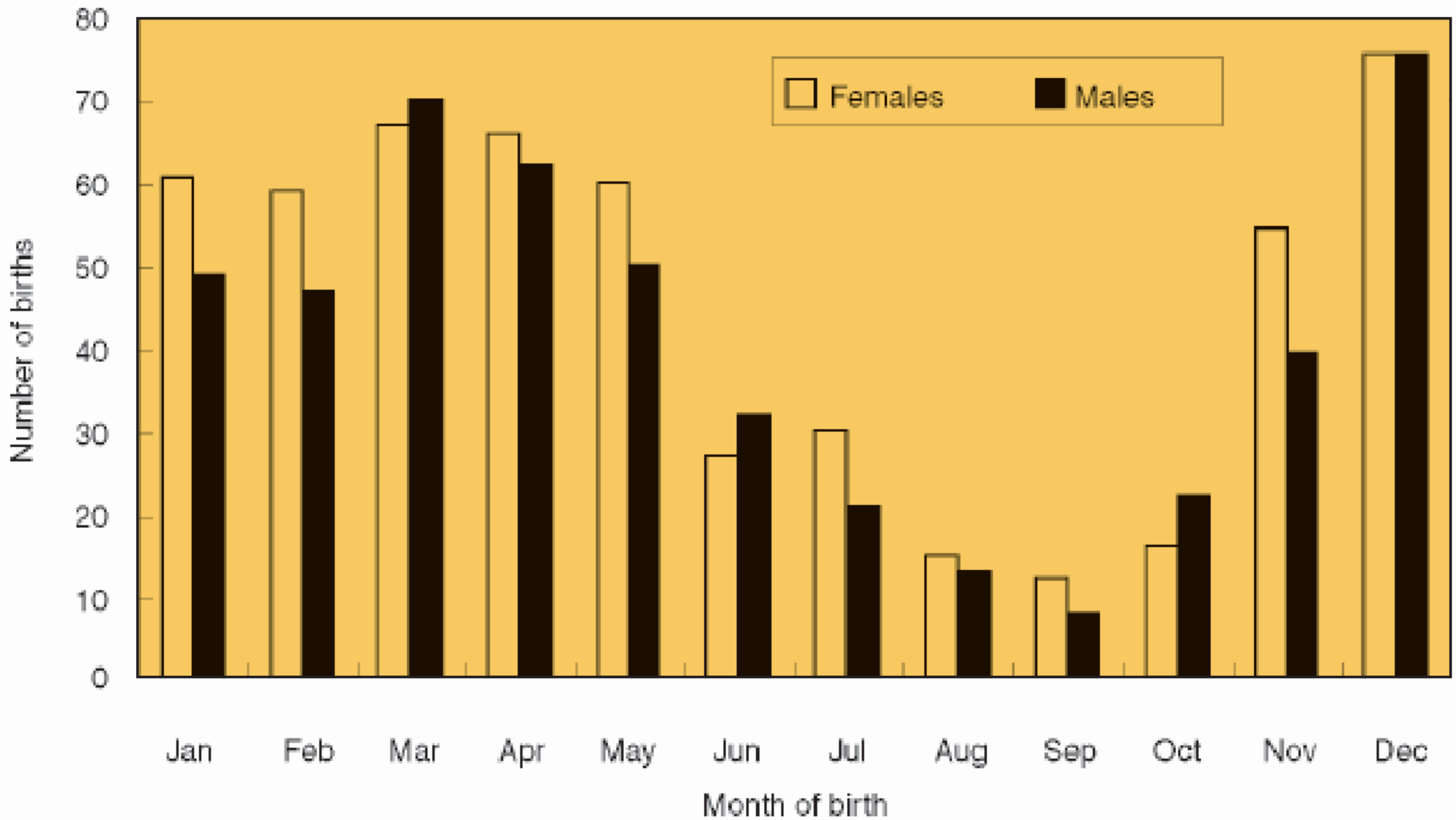
r = “Intrinsic rate of growth”




6. The distribution of births by year, as a proportion of females > 9 years old alive in each year.




. The sex-specific distribution of mortality by year ($n = 691$).




Sex-specific births by month over the period of the study for calves with known birth dates ($n = 1030$).

# Discrete Exponential Growth

Nt = Nt-1 + bNt-1 - dNt-1 + I - E

Ignoring I and E, we get

Nt = (b - d) Nt-1

= r Nt - 1

Try this equation in a spreadsheet.

# Density Dependence

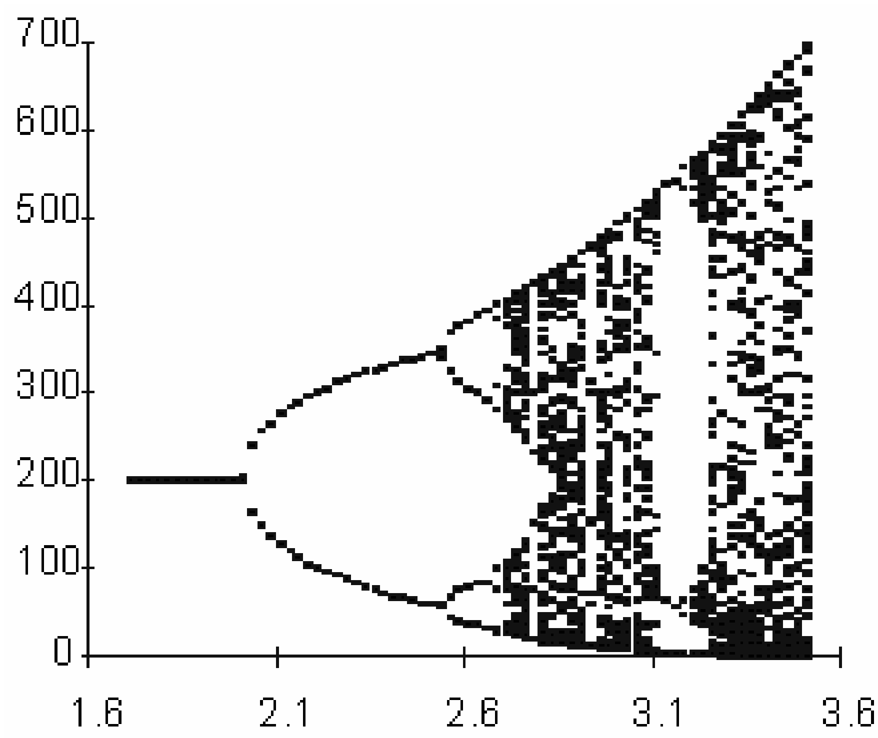
$N_t = rN_{t-1} (1 - N / K)$

“Logistic Growth Equation”

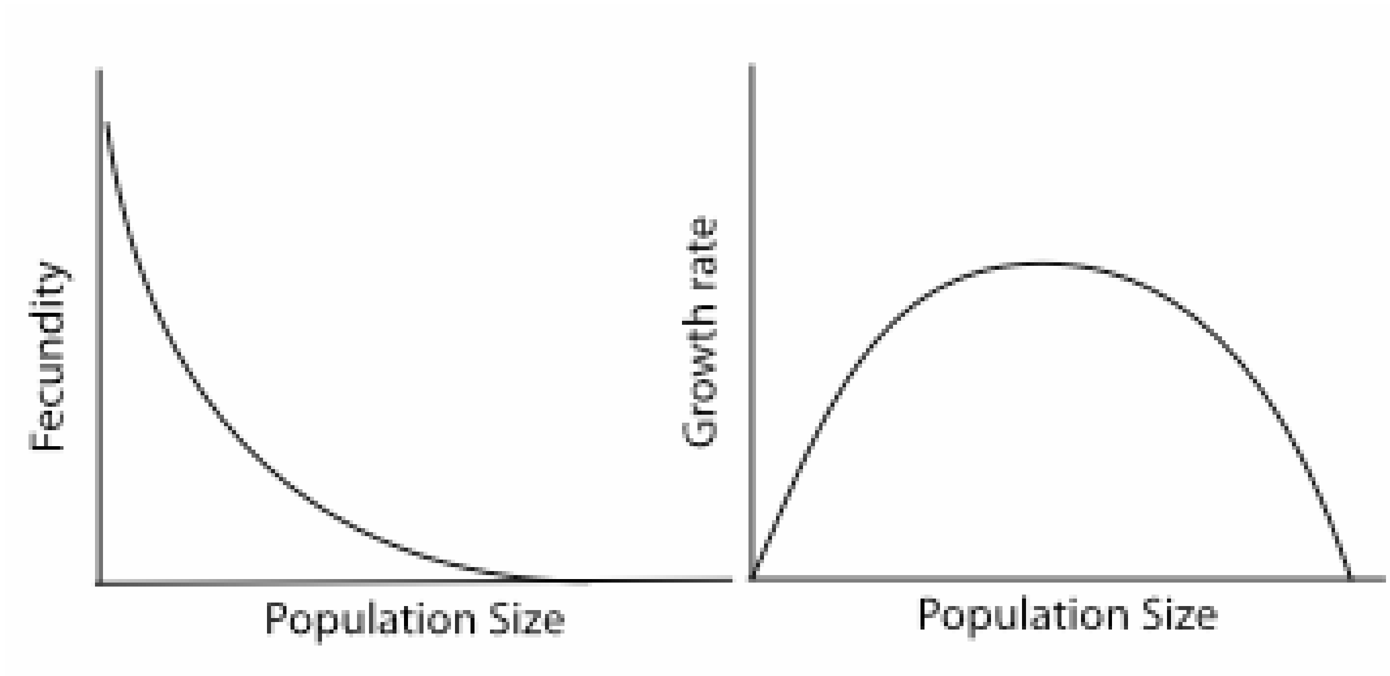
K = Carrying capacity

Try r of different values and graph

# Digression: Chaos



# Digression: Growth rate vs. Population Size




This graph is the basis of population management and harvesting. For instance, the cod fishery might be managed using a graph like this.

Measuring this turns out to be very hard

# Age at First Reproduction

Nt = bNt-a - dNt-1


**Probability of first birth occurring at each age for known-age females.**

Try changing these and see how it affects doubling time

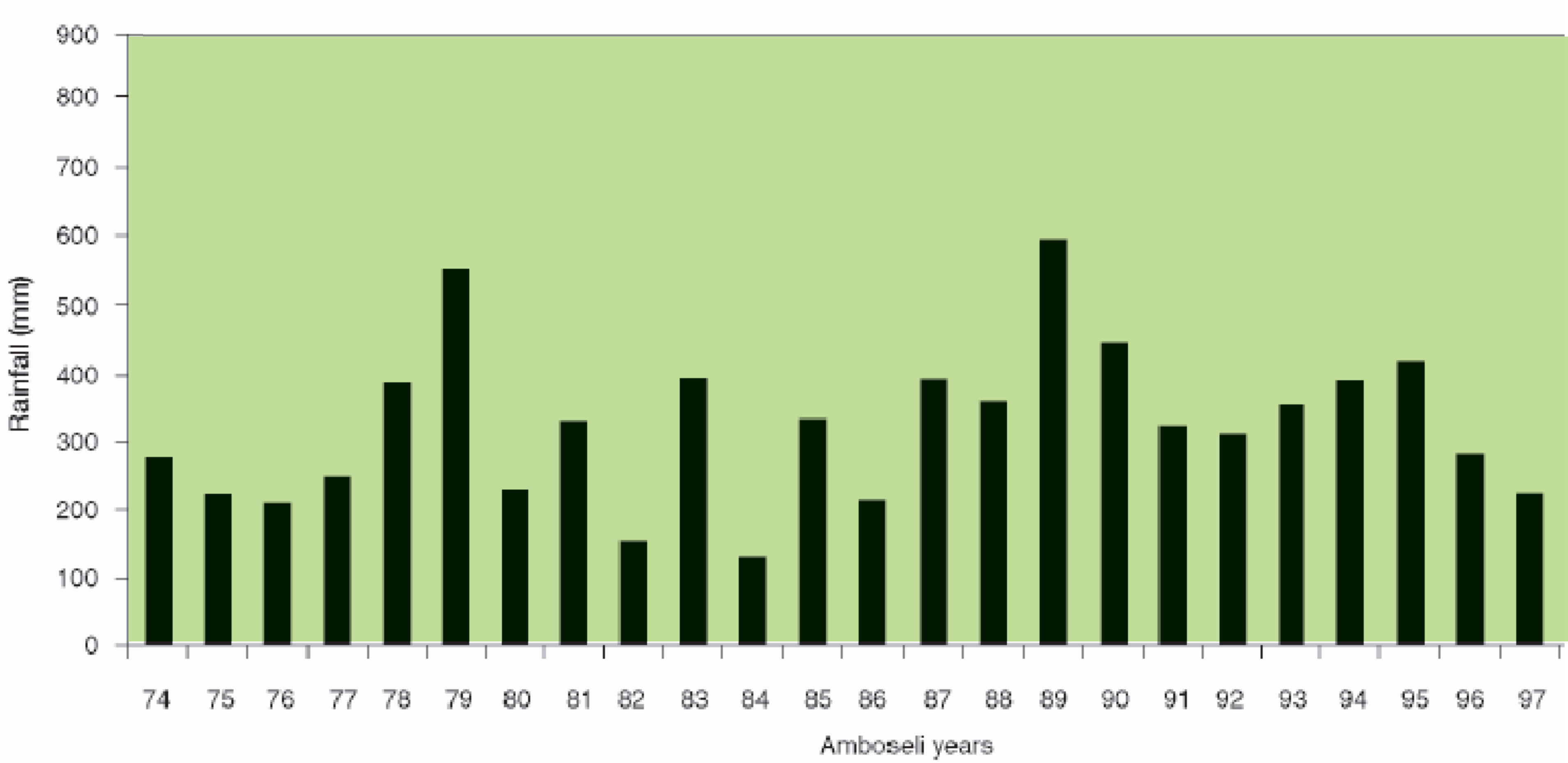
# Digression: Why wait to reproduce?

Obviously, you will have more offspring faster if you reproduce sooner. Why doesn't everything reproduce as soon as its born?

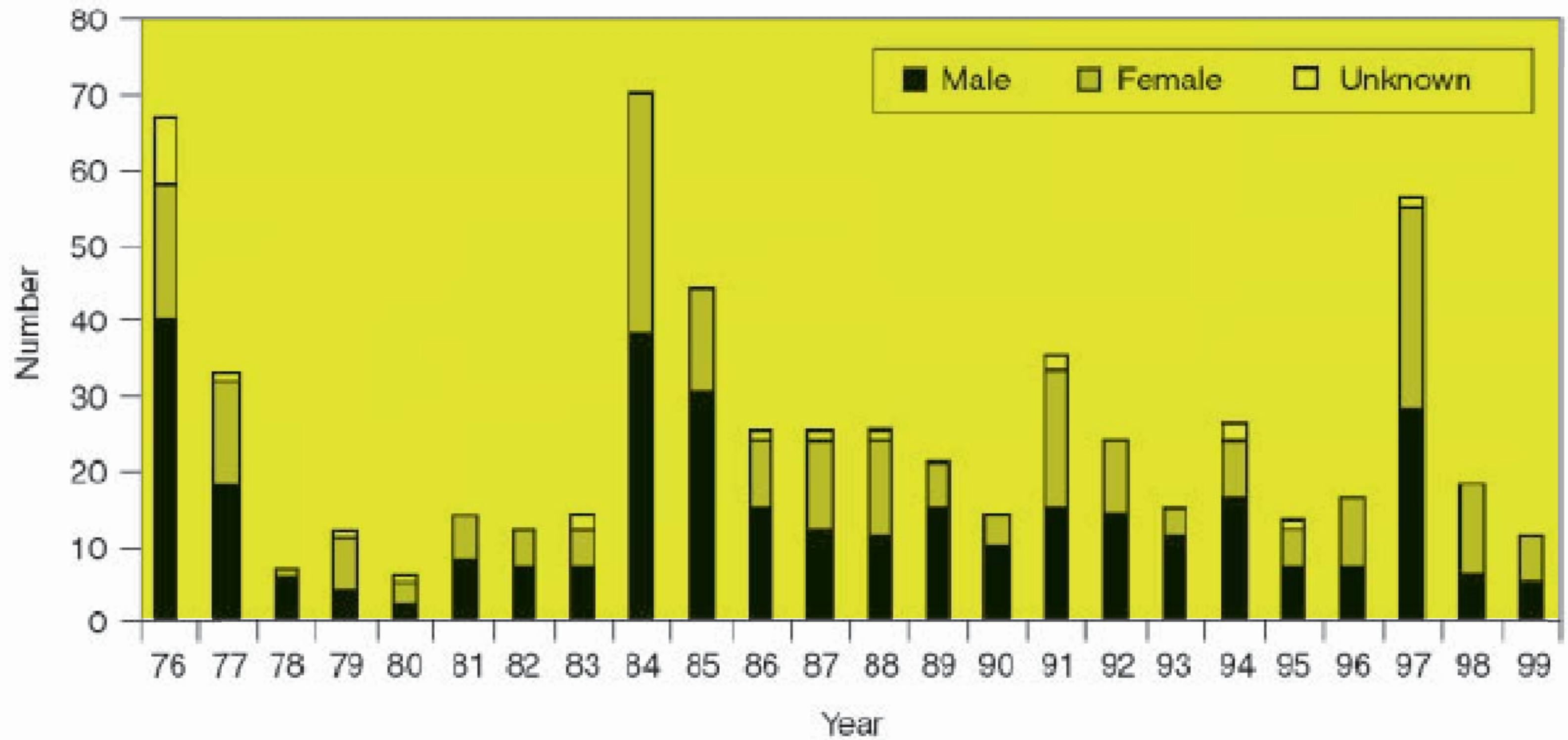
R-selected species: reproduce very at young age and small size / resources.

K-selected species: reproduce at older age and larger size / resources

# Environmental Stochasticity




Rainfall (mm) in ‘Amboseli years’ from 1974–1999.




The sex-specific distribution of mortality by year (*n* = 691).

# Demographic Stochasticity

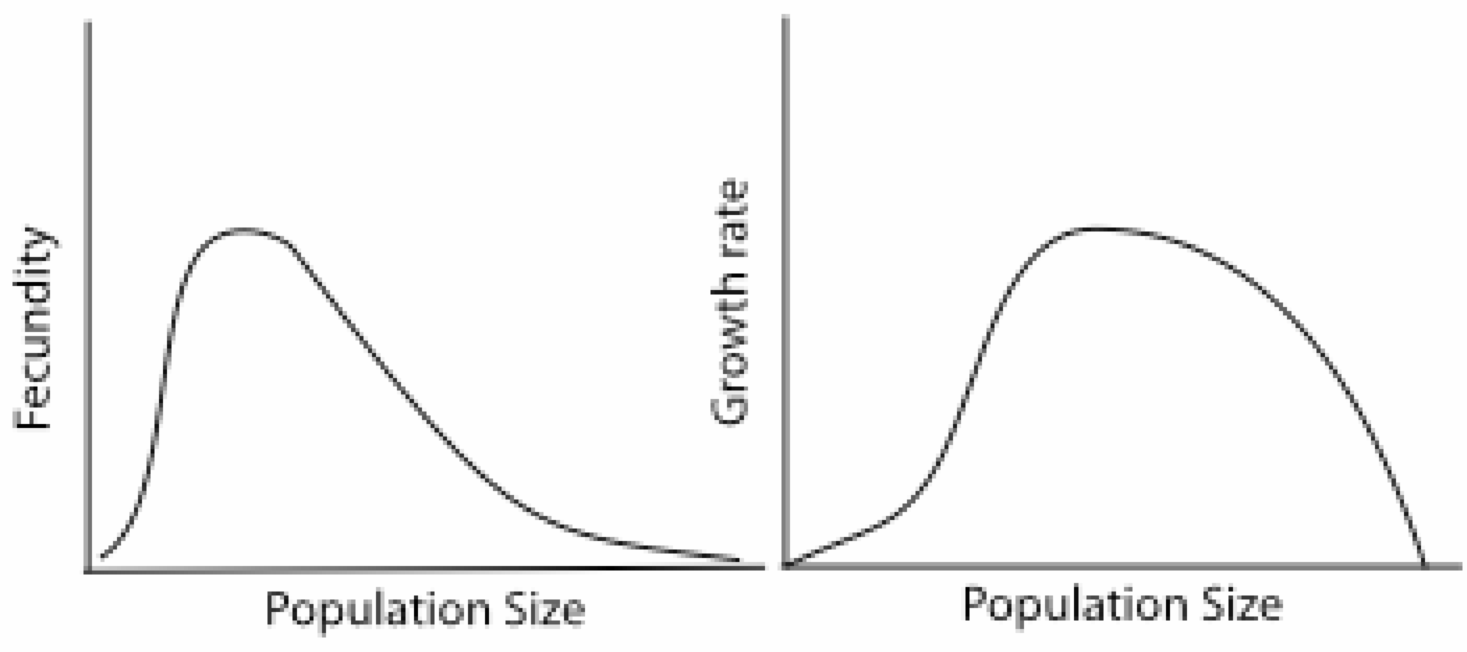
What happens when population is small?

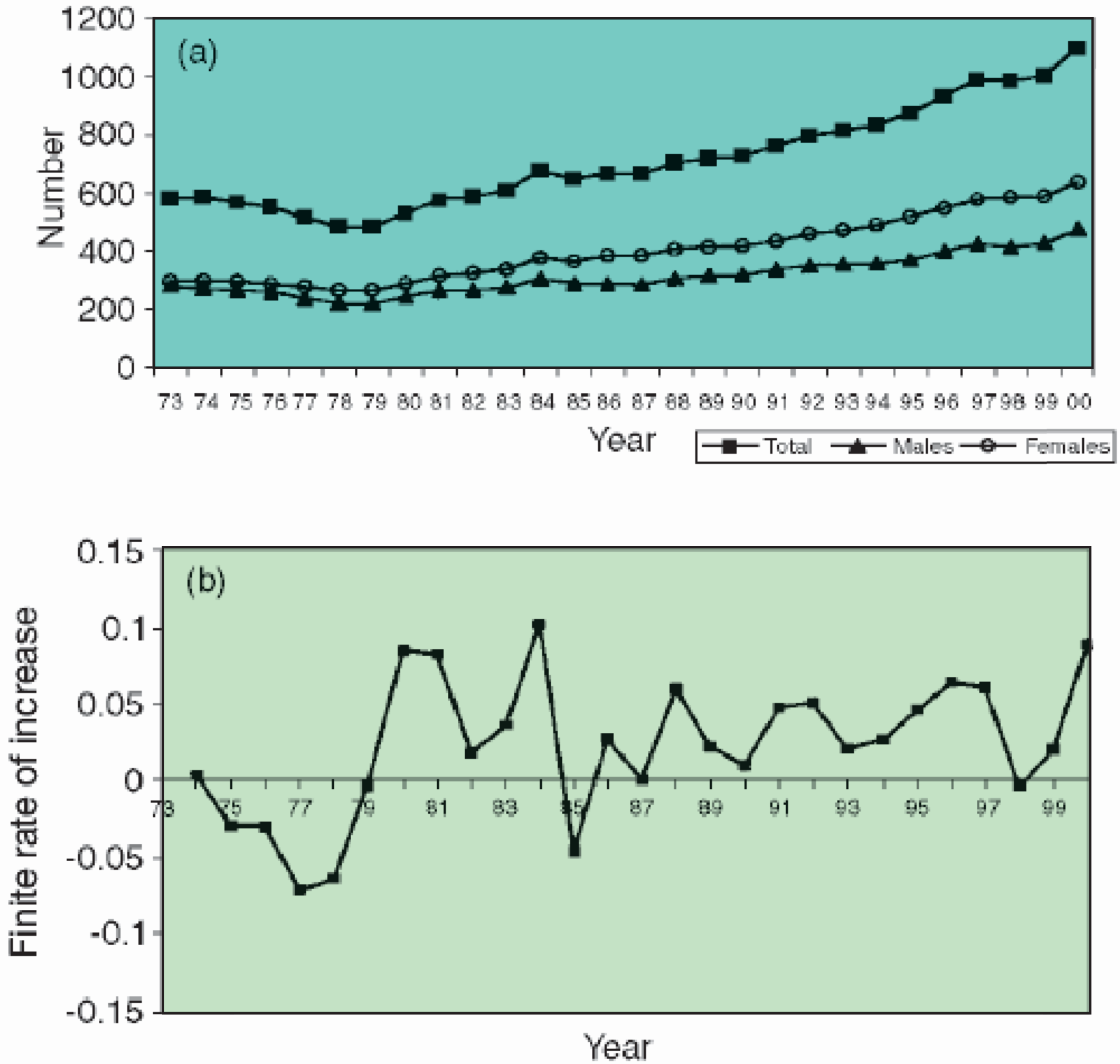
Small numbers means that probability comes into play.

# Allee effect

When population is small, some things may get harder (like finding mates)

If so, fecundity could actually decrease at low population size.






Population trends for Amboseli elephants from 1972 to 1999 (a) sex-specific and total population size by year;

# Some Terms

•Intrinsic rate of growth: maximum offspring / individual / time
•Doubling time: Amount of time for population to double
•Carrying capacity: The maximum population that the environment can sustain
•Discrete vs. continuous: Do events happen continuously or once per some unit of time (such as once per year).
•Density-dependent/ independent: Are the parameters like b and d dependent on the density of the population
•Demographic stochasticity: When populations are low enough, chance events matter to the population size.
•Alee effect: Fecundity decreasing at low population size