Lecture 7

Life tables

WILD3810 (Spring 2020)

Assumptions of the B-D models

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3) Birth and death rates are independent of an individual’s age or biological stage

4) Birth and death rates are constant

Assumptions of the B-D models

In lectures 4 and 5, we learned about ways to model dynamics that do not meet assumption 4:

1) Population closed to immigration and emigration

2) Model pertains to only the limiting sex, usually females

3) Birth and death rates are independent of an individual's age or biological stage

Assumptions of the B-D models

Over the coming weeks, we will learn about why and how to relax assumption 3:

1) Population closed to immigration and emigration

2) Model pertains to only the limiting sex, usually females

4) Birth and death rates are constant

Structured populations

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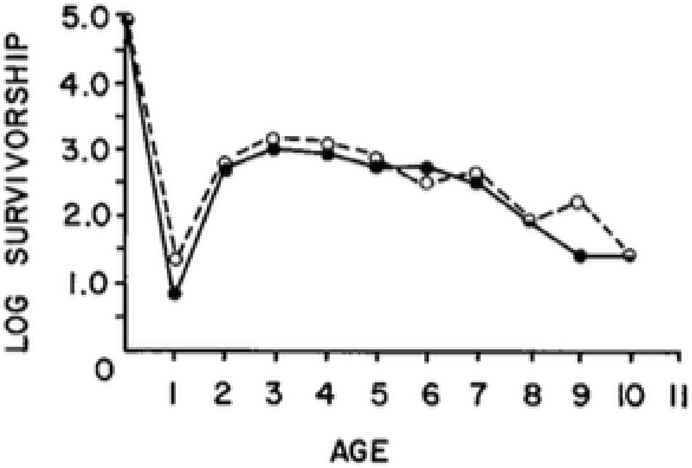
Age-structured populations

Survival and birth rates often vary with age



Stage-structured populations

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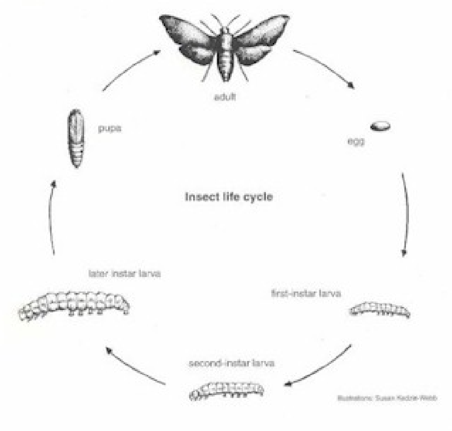
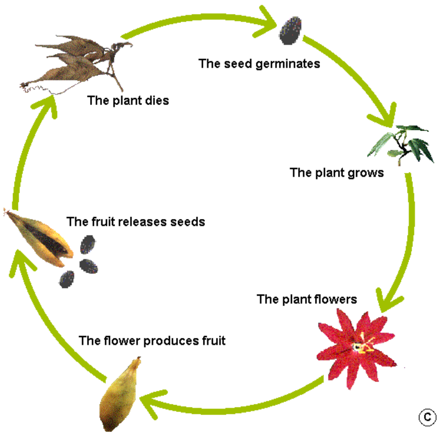
- life cycle stage





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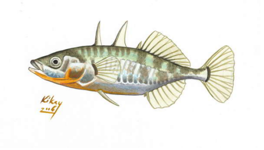
Stage-structured populations

In some cases, age is not a relevant predictor of survival and birth rates

Instead, survival and birth rates vary with

- life cycle stage
- size



Age-structured populations

Age-structured populations

- earliest accounting tool for calculating age-specific survival and mortality

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Applications to:

- Human demography
- Insurance industry (actuarial sciences)
- Health professions

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Applications to:

- Human demography
- Insurance industry (actuarial sciences)
- Health professions

Pearl and Parker (1921) were the first to calculate a non-human life table

- *Drosophila melanogaster* (a fruit fly)

Life tables

Cohort life table

- follow group of individuals born within short period (a) until each individual's death

Life tables

Cohort life table

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- develop life table for groups of individuals with similar traits (e.g., one for males, one for females)

Life tables

Cohort life table

- follow group of individuals born within short period (a) until each individual's death
- develop life table for groups of individuals with similar traits (e.g., one for males, one for females)
- study design

Life tables

- : age of individuals
- : number of individuals observed alive at age (sometimes called)

0	100				
1	75				
2	50				
3	40				

Life tables

- : Probability of surviving to age
  - Can also be interpreted as the proportion of individuals still alive at age
-

0	100				
1	75				
2	50				

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Life tables

- : Probability of surviving to age
-

0	100	1.00			
1	75				
2	50				
3	40				

Life tables

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0	100	1.00			
1	75	0.75			
2	50				
3	40				

Life tables

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0	100	1.00			
1	75	0.75			
2	50	0.50			
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2	50	0.50			
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Life tables

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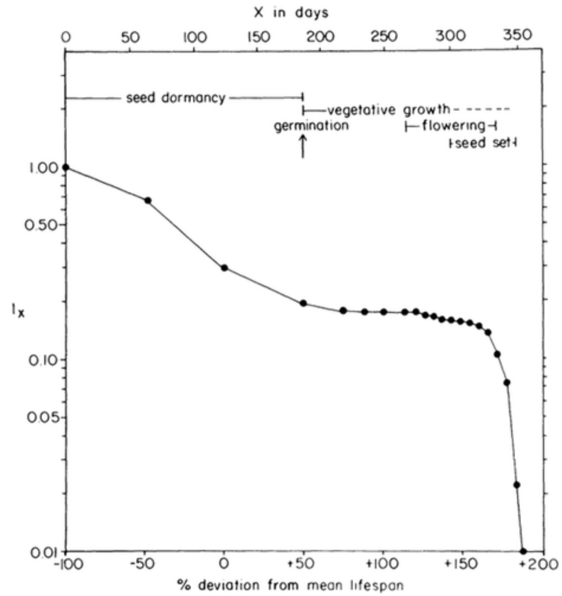
Life tables


X in days
0
50
100
150
200
250
300
350
seed dormancy
vegetative growth
germination
flowering
seed set
1.00
0.50
l_x
0.10
0.05
0.01
-100
-50
0
+50
+100
+150
+200
% deviation from mean lifespan

Life tables

- : Probability of surviving age the next age (of those alive at age)
-

0	100	1.00	0.75		
1	75	0.75			
2	50	0.50			
3	40	0.40			

Life tables

- : Probability of surviving age the next age (of those alive at age)

-

0	100	1.00	0.75		
1	75	0.75	0.667		
2	50	0.50			
3	40	0.40			

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Life tables

- : Probability of surviving age the next age (of those alive at age)

-

0	100	1.00	0.75		
1	75	0.75	0.667		
2	50	0.50	0.8		
3	40	0.40			

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Life tables

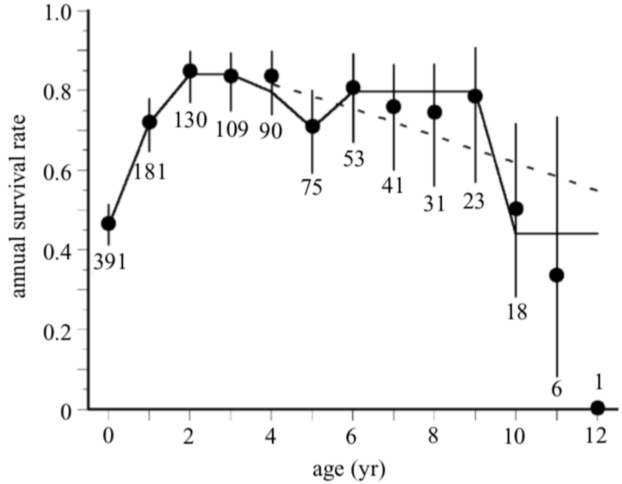
- : Probability of surviving age the next age (of those alive at age)

-

0	100	1.00	0.75		
1	75	0.75	0.667		
2	50	0.50	0.8		
3	40	0.40	0		

Life tables

Age-specific survival of fallow deer (*Dama dama*)



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Life tables

- : Probability of dying age the next age (of those alive at age)
-

0	100	1.00	0.75	0.25	
1	75	0.75	0.667		
2	50	0.50	0.8		
3	40	0.40	0		

Life tables

- : Probability of dying age the next age (of those alive at age)
-

0	100	1.00	0.75	0.25	
1	75	0.75	0.667	0.333	
2	50	0.50	0.8		
3	40	0.40	0		

Life tables

- : Probability of dying age the next age (of those alive at age)
-

0	100	1.00	0.75	0.25	
1	75	0.75	0.667	0.333	
2	50	0.50	0.8	0.2	
3	40	0.40	0		

Life tables

- : Probability of dying age the next age (of those alive at age)
-

0	100	1.00	0.75	0.25	
1	75	0.75	0.667	0.333	
2	50	0.50	0.8	0.2	
3	40	0.40	0	1	

Life tables

Cohort tables

- Assume that all live individuals are available for observation at every age until death
- Most readily applied to:
    - Human populations (e.g., CDC NCHS)
    - Plants
    - Sessile animals
    - Mobile animals on small islands with high observer detection
    - Animals in captivity (zoos)

Life tables

Static tables

- assess number of individuals of known age at one point in time or the age of individuals dying at any point in time

Static life tables

- : Deaths between age and age

0					
1	25				
2	15				
3	10				
4	7				

Static life tables

- : Deaths between age and age

0					
1	25				
2	15				
3	10				
4	7				

Static life tables

- : Deaths between age and age

0		57			
1	25	57-25=32			
2	15	32-15=17			
3	10	17-10=7			
4	7	7-7=0			

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Static life tables

- : Deaths between age and age

0		57	1.00	0.56	
1	25	57-25=32	0.56	0.54	
2	15	32-15=17	0.30	0.4	
3	10	17-10=7	0.12	0	
4	7	7-7=0	0.00	-	

Static life tables

Static life tables most readily applied to:

- Plants and animals where age can be accurately determined for all individuals at a given moment in time
- e.g., using the rings/layering in trees, teeth, otoliths, horns, and maybe even telomere length on genes

Static life tables

Static life table assumptions:

- All individuals have equivalent availability for observation, regardless of age
- Stable age distribution
- Age-specific survival does not change over time
    - If it does, time effects may appear as 'age effects' and lead to biased results

Survivorship curves

Survivorship curves

Survivorship curves

(Pearl 1928)

Survivorship curves

Survivorship curves

What types of species do you expect have type 1 survivorship curves?

Survivorship curves

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Survivorship curves

What types of species do you expect have type 2 survivorship curves?

Survivorship curves

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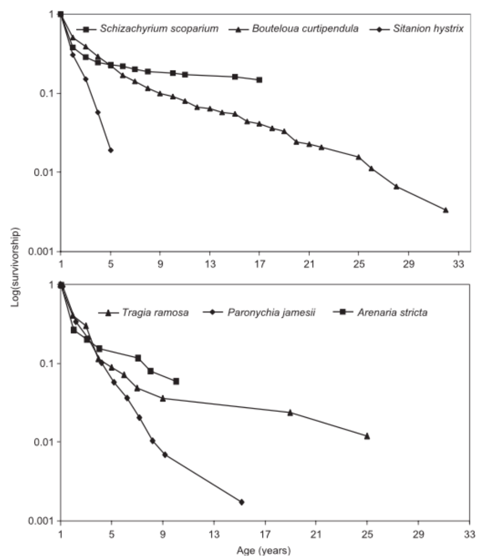
Survivorship curves

What types of species do you expect have type 3 survivorship curves?

Survivorship curves

What types of species do you expect have type 3 survivorship curves?



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Life expectancy

Life expectancy

Life Expectancy

> The average length of time an individual is expected to live, given they are currently years old

- Directly related to the probability of surviving to a given age

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Utah has the lowest per capita crude death rate in the U.S. (averaged across all ages)

Life expectancy

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> The average length of time an individual is expected to live, given they are currently years old

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Life expectancy

To estimate life expectancy, start with

- = Proportion of individuals still alive at age

0	100	1.00			
1	75	0.75			
2	50	0.50			
3	40	0.40			

Life expectancy

- : Average proportion of living individuals across successive age classes

0	100	1.00	0.875		
1	75	0.75	0.65		
2	50	0.50	0.5		

Life expectancy

- : total proportion of living individuals from age to

Life expectancy

- : total proportion of living individuals from age to

Life expectancy

- : total proportion of living individuals from age to
-

0	100	1.00	0.875	2.23	
1	75	0.75	0.65	1.35	
2	50	0.50	0.5	0.7	
3	40	0.40	0.2	0.2	

Life expectancy

- : Number of additional years an individual of age is expected to survive
-

0	100	1.00	0.875	2.23	2.23
1	75	0.75	0.65	1.35	1.93
2	50	0.50	0.5	0.7	1.17
3	40	0.40	0.2	0.2	0.5

Utah life expectancy

Utah has the lowest per capita crude death rate d in the U.S

Can Utahns expect to live longer than all other states?

Utah life expectancy

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Not exactly

- Life expectancy of a newborn Utahn is 80.2

Utah life expectancy

Utah has the lowest per capita crude death rate d in the U.S

Can Utahns expect to live longer than all other states?

Not exactly

- Life expectancy of a newborn Utahn is 80.2
- Ranked 10th in the U.S., not first

Utah life expectancy

Why is Utah’s crude per capita death rate so low?

Utah life expectancy

Why is Utah’s crude per capita death rate so low?

Because Utah has the highest birth rate and consequently the youngest age structure

- % of Utahns < 18 yrs old is 32%
- % of U.S. < 18 yrs old is 25%

Utah life expectancy

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- % of Utahns ≥ 65 is 11%
- % of U.S. ≥ 65 = 15%

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- % of Utahns < 18 yrs old is 32%
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Young individuals have highest chances of survival