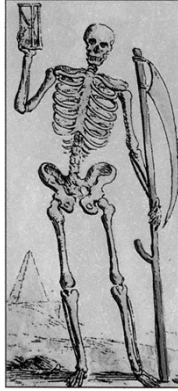


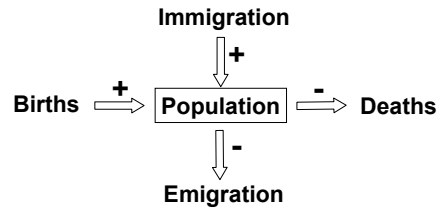
Populations: Mortality and Survival

"I don't want to achieve immortality through my work.
I want to achieve it through not dying."
— Woody Allen



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Population Dynamics



changes in population size that result from variations in the rates of birth, death and movement of individuals

Mortality Factors

- Physiological longevity: max lifespan set by genetics
 - rarely achieved in nature
- Extrinsic factors:
 - **Abundance of predators / parasites / resources**
 - **Population density**
 - mortality rates often rise as population density increases (**density dependent mortality**).
 - **Experience of individuals**
 - Animals in a strange environment are at greater risk.

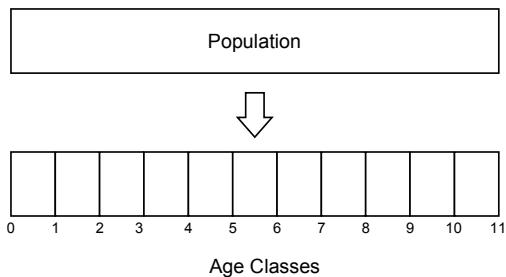
Page 2

Mortality Factors (cont.)

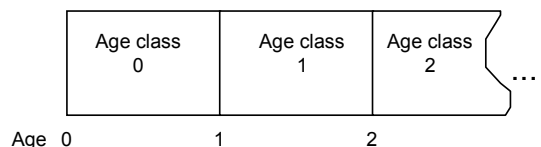
- **Sex**
 - Differences tied to roles and risks associated with reproduction.
 - Mammals?
 - Birds?
- **Season**
 - highest risk during most stressful seasons.
 - Seasonal migrations
 - Breeding seasons
 - e.g. moose & deer
- **Age**

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Age-related Mortality



Age-related Mortality



$n_0 =$ # newborns $n_1 =$ # surviving to 1 year old

deaths in age class 0 = $d_0 = n_0 - n_1$

mortality rate in age class 0 = $q_0 = d_0/n_0$

Life Tables

- **Life table** = summary of age-specific mortality rates of a population

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Life Tables

| Age class (years) (x) | Number in population (n_x) | Number of deaths (d_x) | Mortality rate (q_x) | Survival rate (s_x) | Cumulative survival rate (l_x) |
|---------------------------|--------------------------------|----------------------------|--------------------------|-------------------------|------------------------------------|
| 0 | 42 | | | | |
| 1 | 20 | | | | |
| 2 | 10 | | | | |
| 3 | 3 | | | | |
| 4 | 1 | | | | |

- x = age class
- n_x = number of animals surviving to the **beginning** of age class x .
- d_x = the number of deaths in the age class $d_x = n_x - n_{x+1}$
- q_x = the mortality rate in age class. $q_x = d_x/n_x$
- s_x = the survival rate in age class. $s_x = 1 - q_x$
- l_x = the cumulative survival rate from birth until age x . $l_x = n_x/n_0$

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Life Tables

| Age (years) (x) | Number in population (n_x) | Number of deaths (d_x) | Mortality rate (q_x) | Survival rate (s_x) | Cumulative survival rate (l_x) |
|---------------------|--------------------------------|----------------------------|--------------------------|-------------------------|------------------------------------|
| 0 | 42 | 22 | | | |
| 1 | 20 | 10 | | | |
| 2 | 10 | 7 | | | |
| 3 | 3 | 2 | | | |
| 4 | 1 | 1 | | | |

- x = age class
- n_x = number of animals surviving to the beginning of age class x .
- d_x = the number of deaths in the age class $d_x = n_x - n_{x+1}$
- q_x = the mortality rate in age class. $q_x = d_x/n_x$
- s_x = the survival rate in age class. $s_x = 1 - q_x$
- l_x = the cumulative survival rate from birth until age x . $l_x = n_x/n_0$

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Life Tables

| Age (years) (x) | Number in population (n_x) | Number of deaths (d_x) | Mortality rate (q_x) | Survival rate (s_x) | Cumulative survival rate (l_x) |
|---------------------|--------------------------------|----------------------------|--------------------------|-------------------------|------------------------------------|
| 0 | 42 | 22 | 22/42 = 0.52 | 0.48 | |
| 1 | 20 | 10 | 10/20 = 0.50 | 0.50 | |
| 2 | 10 | 7 | 7/10 = 0.70 | 0.30 | |
| 3 | 3 | 2 | 2/3 = 0.67 | 0.33 | |
| 4 | 1 | 1 | 1/1 = 1.00 | 0.00 | |

- x = age class
- n_x = number of animals surviving to the beginning of age class x .
- d_x = the number of deaths in the age class $d_x = n_x - n_{x+1}$
- q_x = the mortality rate in age class. $q_x = d_x/n_x$
- s_x = the survival rate in age class. $s_x = 1 - q_x$
- l_x = the cumulative survival rate from birth until age x . $l_x = n_x/n_0$

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Life Tables

| Age class (years) (x) | Number at start (n_x) | Number of deaths (d_x) | Mortality rate (q_x) | Survival rate (s_x) | Cumulative survival rate (l_x) |
|---------------------------|---------------------------|----------------------------|--------------------------|-------------------------|------------------------------------|
| 0 | 42 | 22 | 22/42 = 0.52 | 0.48 | 42/42 = 1.00 |
| 1 | 20 | 10 | 10/20 = 0.50 | 0.50 | 20/42 = 0.48 |
| 2 | 10 | 7 | 7/10 = 0.70 | 0.30 | 10/42 = 0.24 |
| 3 | 3 | 2 | 2/3 = 0.67 | 0.33 | 3/42 = 0.07 |
| 4 | 1 | 1 | 1/1 = 1.00 | 0.00 | 1/42 = 0.02 |

- x = age class
- n_x = number of animals surviving to the beginning of age class x .
- d_x = the number of deaths in the age class $d_x = n_x - n_{x+1}$
- q_x = the mortality rate in age class. $q_x = d_x/n_x$
- s_x = the survival rate in age class. $s_x = 1 - q_x$
- l_x = the cumulative survival rate from birth until age x . $l_x = n_x/n_0$

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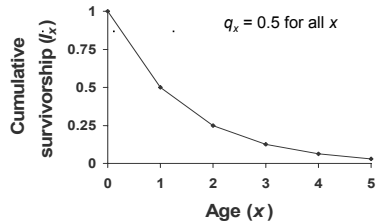
Kinds of Life Tables

- **THE HARDEST PART OF CONSTRUCTING A LIFE TABLE IS COLLECTING THE DATA**
- **cohort life table** - follow a cohort (one similarly aged group) through time
 - Best method, but difficult for long-lived animals
- **static life table** – observe age structure of a population at a specific time or collect corpses and determine age
 - Inferring mortality rates from age structure requires assumptions
 - Static population (zero growth)
 - No immigration / emigration
 - Age-specific mortality is constant over time

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Survivorship Curves

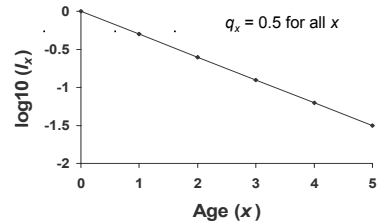
If mortality rate is the same for all age classes
($q_0 = q_1 = q_2 \dots$) then l_x (or n_x) exhibits **exponential decay**



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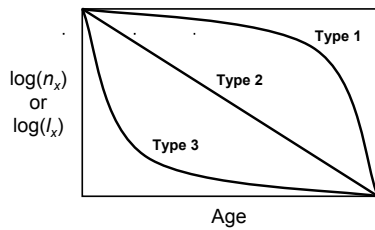
Survivorship Curves

If mortality rate is the same for all age classes
($q_0 = q_1 = q_2 \dots$) then l_x (or n_x) exhibits **exponential decay**
MAKES A STRAIGHT LINE ON LOGARITHMIC SCALE



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Survivorship Curves

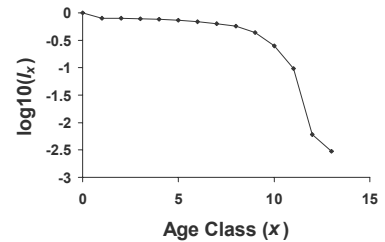


- Type 1: mortality rate increases with age (convex)
- Type 2: mortality rate constant (linear)
- Type 3: mortality rate decreases with age (concave)

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Survivorship Curve: Murie 1944

- Dall sheep (*Ovis dalli*) in Mt. McKinley N.P.
- based on ages measured from 608 skulls



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Things to Remember

- Defs: Population & population dynamics
- Processes that drive pop. dynamics
- Factors affecting mortality rates
- **LIFE TABLE**
- Survivorship curve shapes – what they mean