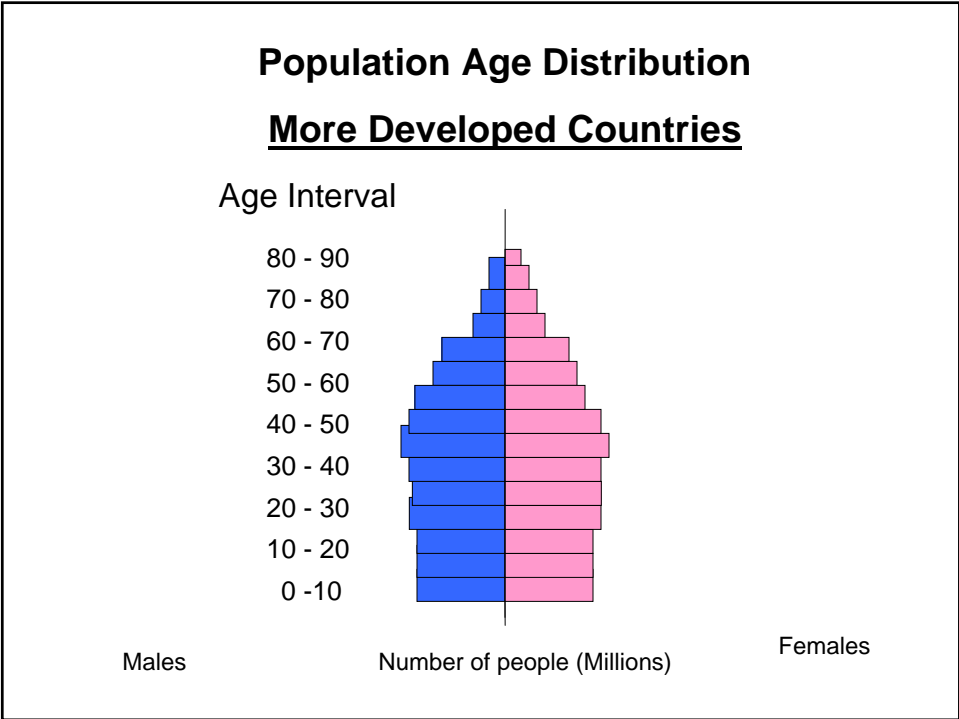
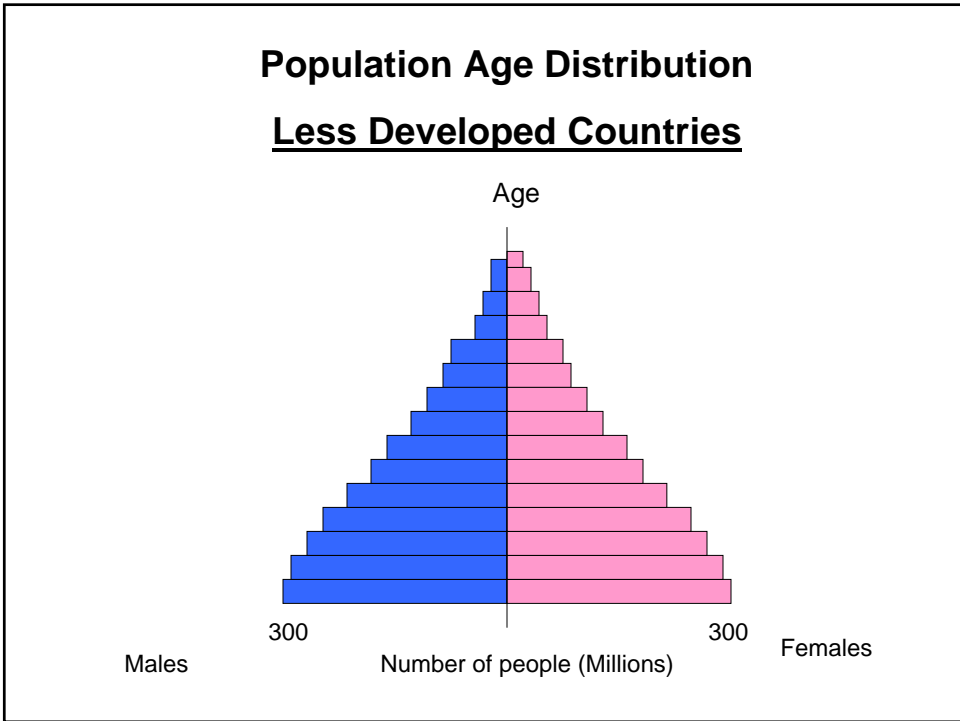
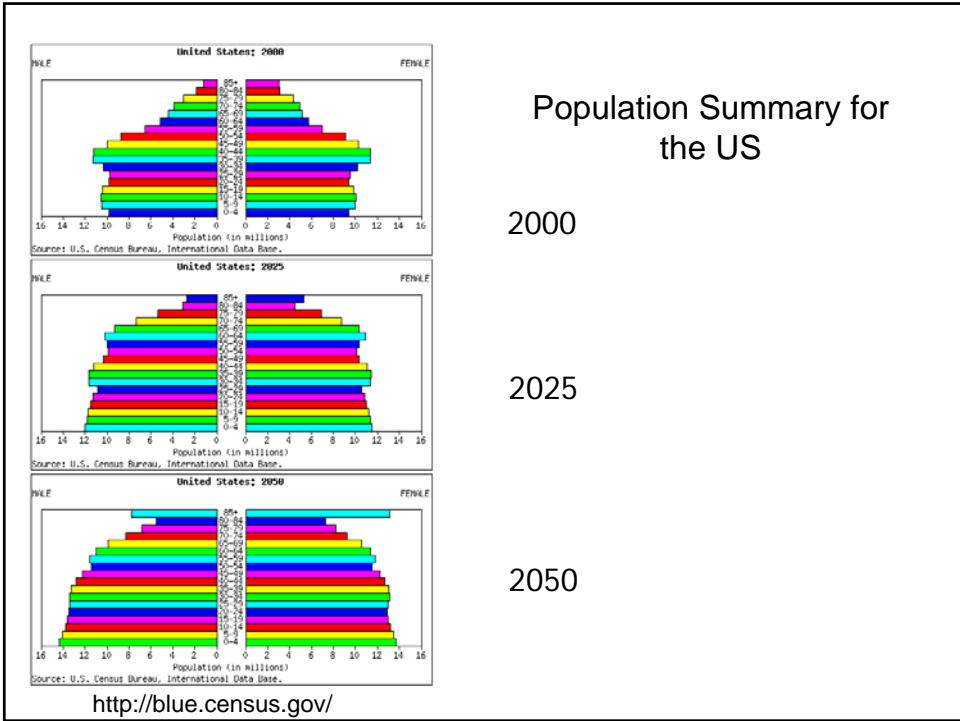
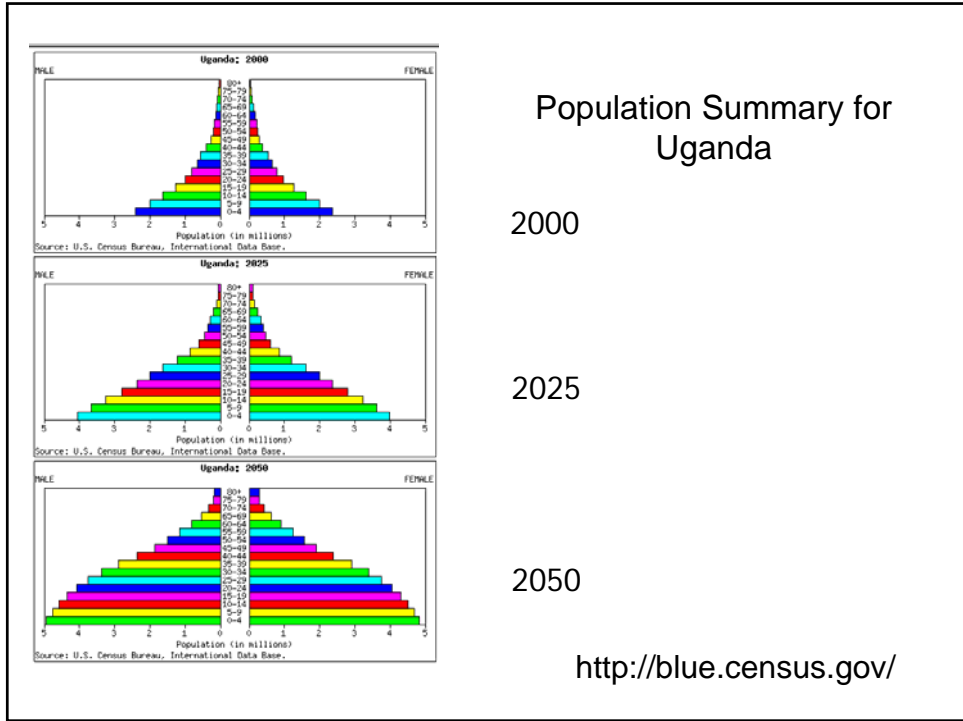


7.014
Lecture 29 & 30:
Population Growth
Lecture Slides
April 25 & 27, 2005







Life Tables

x = age or interval (defined)

N_0 = number of individuals in original cohort (defined)

d_x = number of original cohort *dying* during interval

N_x = number of individuals *surviving* to age x (measured)

l_x = proportion of individuals surviving to age x

$$l_x = N_x / N_0$$

m_x = per capita births during age interval x to $x+1$ (measured)

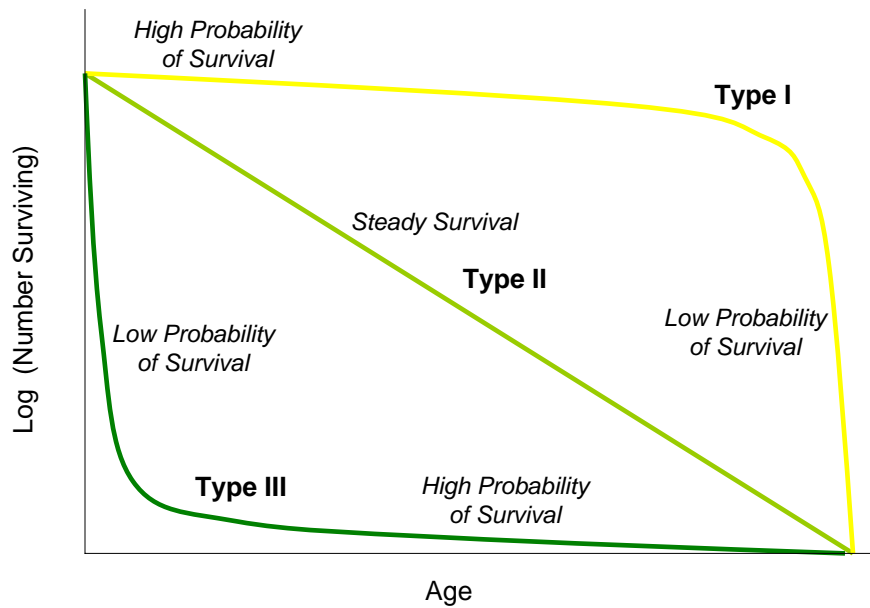
“age specific fecundity” = female offspring produced per female

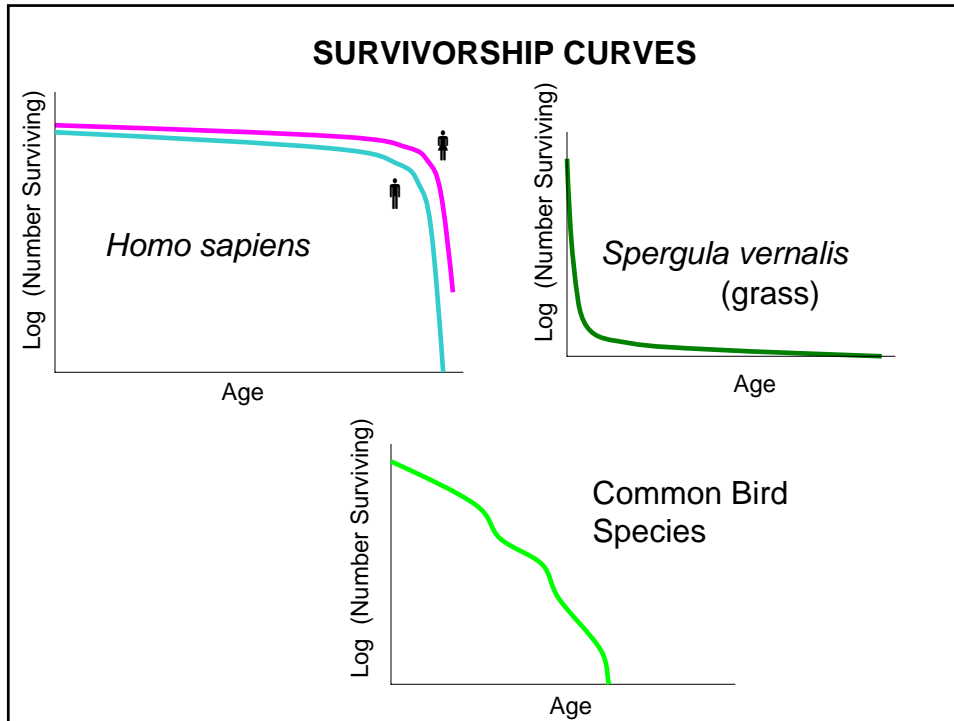
A COHORT LIFE TABLE (for Unicorns)

$N_0 = 100$

| Age | Number Surviving | Proportion Surviving |
|----------|----------------------|----------------------|
| X | N_x | I_x |
| 0 | 100 | 1.0 |
| 1 | 50 | .5 |
| 2 | 40 | .4 |
| 3 | 30 | .3 |
| 4 | 0 | 0 |

SURVIVORSHIP CURVES





A COHORT LIFE TABLE (for Unicorns)

$N_0 = 100$

| Age | Number Surviving | Proportion Surviving | Average Offspring per female of age x |
|----------|----------------------|----------------------|---------------------------------------|
| X | N_x | l_x | m_x |
| 0 | 100 | 1.0 | 0 |
| 1 | 50 | .5 | 4 |
| 2 | 40 | .4 | 2.5 |
| 3 | 30 | .3 | 0 |
| 4 | 0 | 0 | 0 |

A COHORT LIFE TABLE (for Unicorns)

$N_0 = 100$

| Age | Number Surviving | Proportion Surviving | Average Offspring per female of age x | Realized Fecundity Values |
|----------|----------------------|----------------------|---------------------------------------|-----------------------------------|
| X | N_x | l_x | m_x | l_xm_x |
| 0 | 100 | 1.0 | 0 | 0 |
| 1 | 50 | .5 | 4 | 2 |
| 2 | 40 | .4 | 2.5 | 1 |
| 3 | 30 | .3 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

$$R_0 = \sum l_x m_x = 3$$

$R_0 =$ Net Replacement

A STATIC LIFE TABLE (for Unicorns)

Sample of 100 unicorns $N_0 = 100$

| Age Interval | Number Surviving at Beginning of X | Number Dying | Proportion Surviving by Age X |
|--------------|------------------------------------|----------------|-------------------------------|
| X | N _x | d _x | l _x |
| 0 | 100 | 50 | 1.0 |
| 1 | 50 | 10 | .5 |
| 2 | 40 | 10 | .4 |
| 3 | 30 | 30 | .3 |
| 4 | 0 | 0 | 0 |

A COHORT LIFE TABLE (for Unicorns)

$N_0 = 100$

| Age | Number Surviving | Proportion Surviving | Average Offspring per female of age x | Realized Fecundity Values | |
|-----|------------------|----------------------|---------------------------------------|---------------------------|-------------|
| X | N_x | l_x | m_x | $l_x m_x$ | $l_x m_x X$ |
| 0 | 100 | 1.0 | 0 | 0 | 0 |
| 1 | 50 | .5 | 4 | 2 | 2 |
| 2 | 40 | .4 | 2.5 | 1 | 2 |
| 3 | 30 | .3 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 |

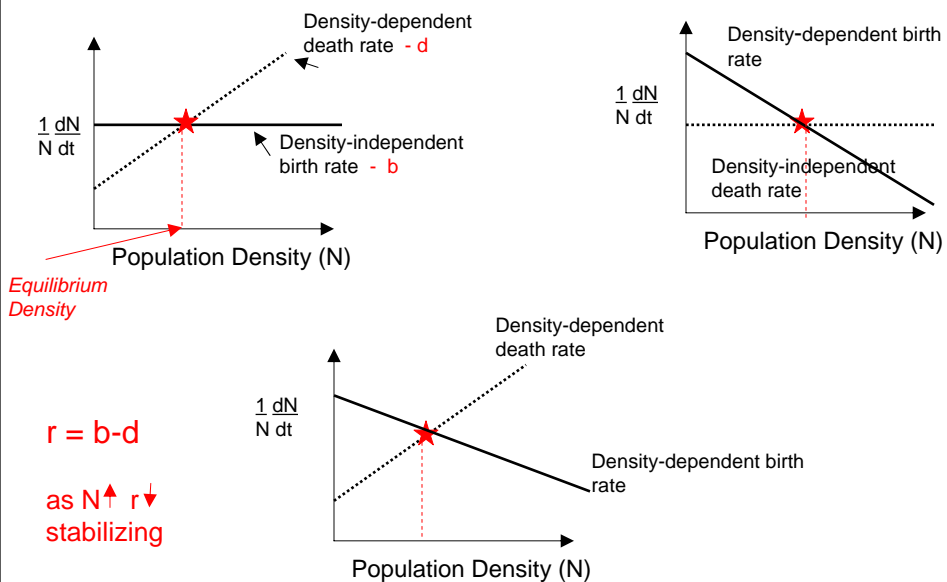
$$R_0 = \text{Net Replacement} = \sum l_x m_x = 3$$

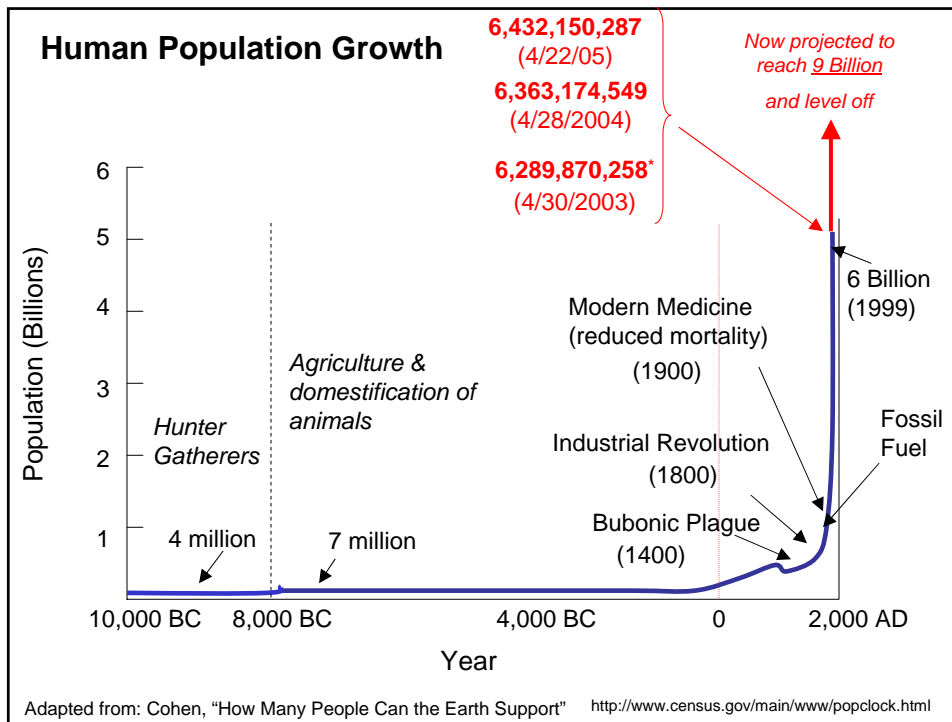
$$G \sim (\sum l_x m_x X) / (\sum l_x m_x) = (\sum l_x m_x X) / R_0 = 4/3 \text{ years}$$

Intrinsic Rate of Increase

$$r \approx (\ln R_0) / G \approx (\ln 3) / 1.33 \approx 0.82 \text{ yr}^{-1}$$

Density-Dependant Factors Regulate Population Size



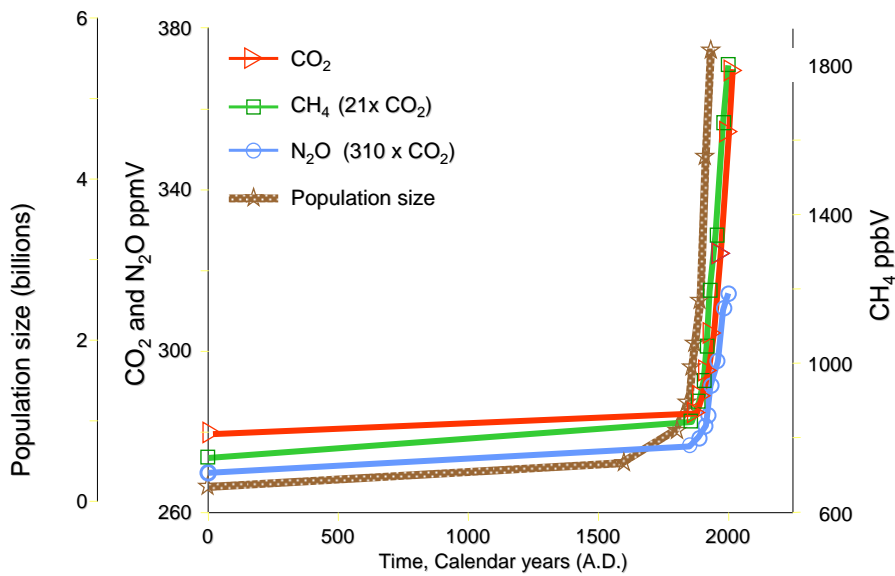


Four "Evolution" in Human Population Growth

| Evolution Driver | Midpoint | Population (billions) | Doubling Time (years) before | Doubling Time (years) after |
|--------------------|-----------|-----------------------|------------------------------|-----------------------------|
| Local Agriculture | 8000 B.C. | 0.005 | 40,000 - 300,000 | 1,400 - 3,000 |
| Global Agriculture | 1750 A.D. | 0.75 | 750 - 1,800 | 100 - 130 |
| Public Health | 1950 | 2.5 | 87 | 36 |
| Fertility Control | 1970 | 3.7 | 34 (peak) | >40 (since 1990) |

Adapted from: Cohen, "How Many People Can the Earth Support"

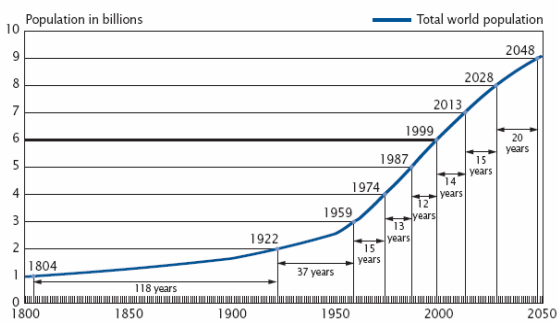
and recall from lecture 20.....



Falkowski and Tchernov 2004

<http://www.census.gov/ipc/prod/wp02/wp02-1.pdf>

Figure 1.
Annual Additions and the Annual Growth Rate of Global Population
The growth of global population has peaked.



Source: United Nations, *World Population Prospects: The 1994 Revision*; U.S. Census Bureau, International Programs Center, International Data Base and unpublished tables.

USCENSUSBUREAU

U.S. Department of Comm
 Economics and Statistics Administr
 U.S. CENSUS BUREAU

Demographic Transition

