7.014

Lecture 29 & 30:

Population Growth

Lecture Slides

April 25 & 27, 2005

Population Age Distribution

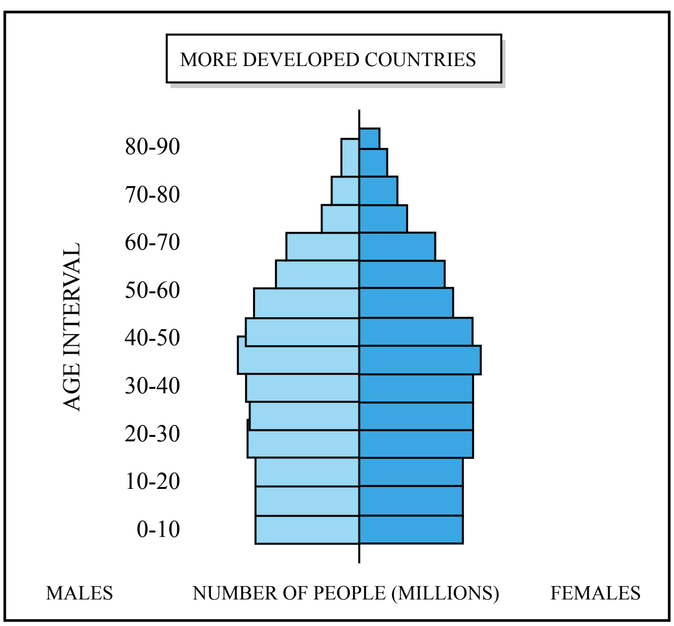
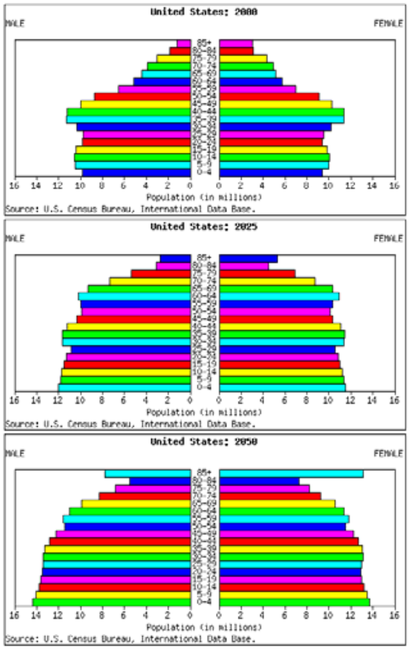


Figure by MIT OCW.



http://blue.census.gov/

Population Summary for the US

2000

2025

2050

Population Age Distribution

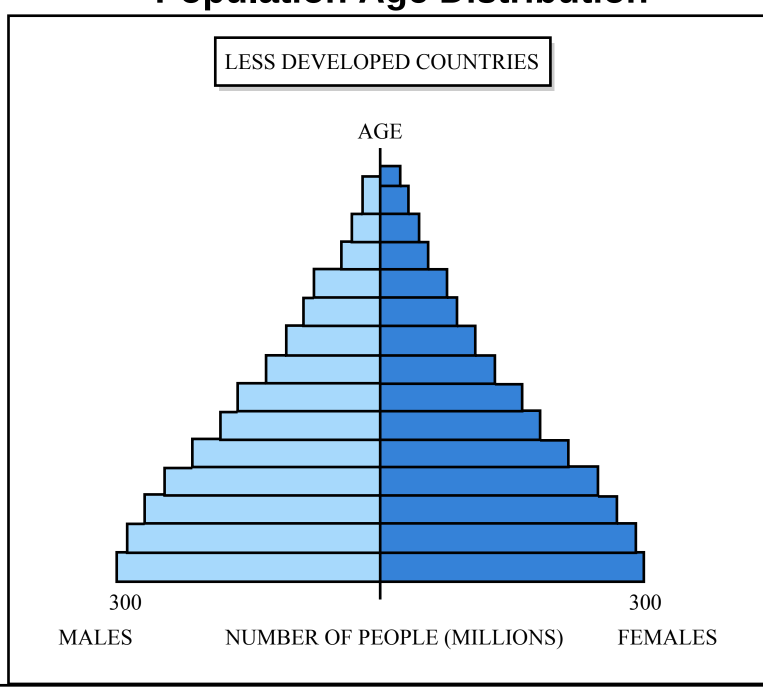
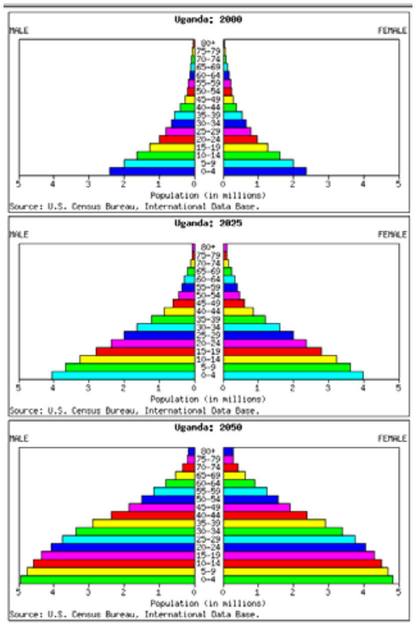


Figure by MIT OCW.



Population Summary for Uganda

2000

2025

2050

http://blue.census.gov/

Life Tables

x = age or interval (defined)

$\mathbf{N_0}$ = number of individuals in original cohort (defined)

$\mathbf{d_x}$ = number of original cohort *dying* during interval

$\mathbf{N_x}$ = number of individuals *surviving* to age x (measured)

$\mathbf{l_x}$ = proportion of individuals surviving to age x

$$l_x = N_x / N_0$$

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

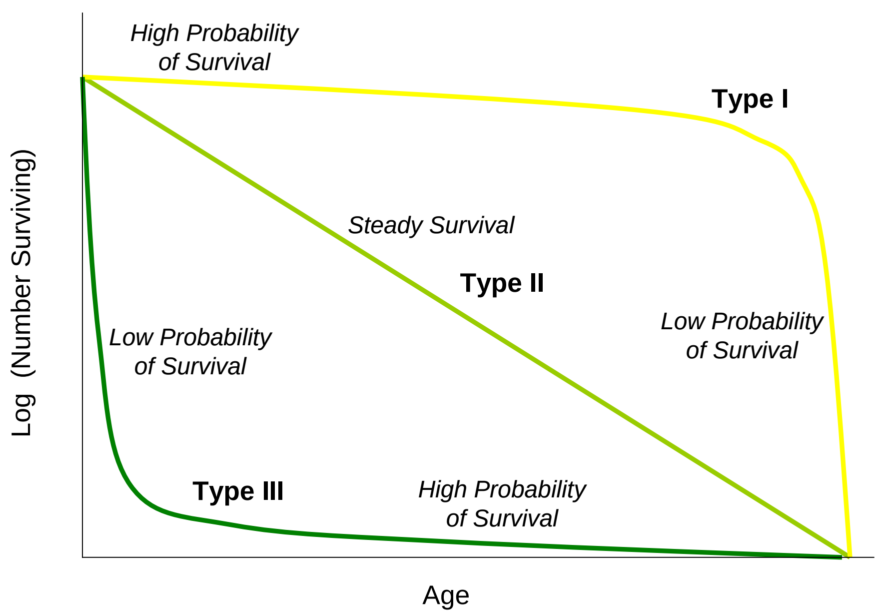
"age specific fecundity" = female offspring produced per female

A COHORT LIFE TABLE (for Unicorns)

$N_0 = 100$

Age	Number Surviving	Proportion Surviving
X	**N_x**	**l_x**
0	100	1.0
1	50	.5
2	40	.4
3	30	.3
4	0	0

SURVIVORSHIP CURVES



SURVIVORSHIP CURVES

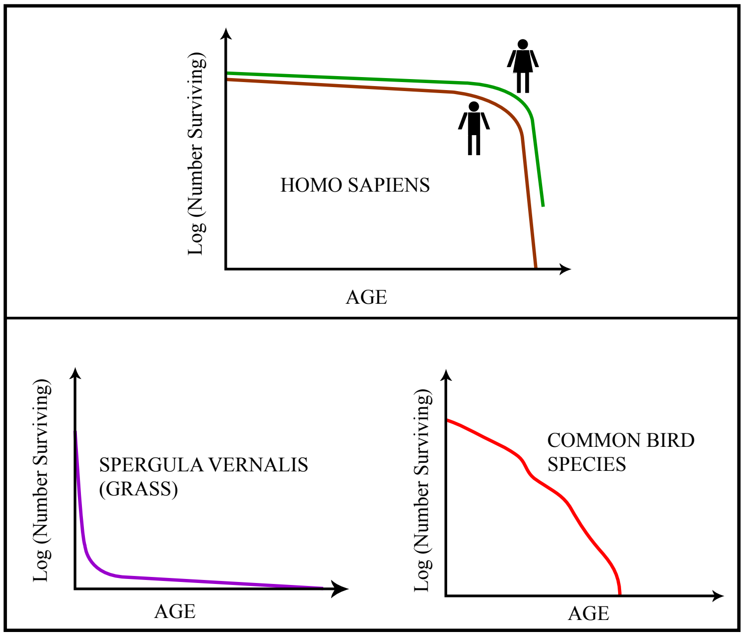


Figure by MIT OCW.

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**	**$l_x m_x$**
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

$R_0 = \Sigma\ l_x m_x = 3$

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

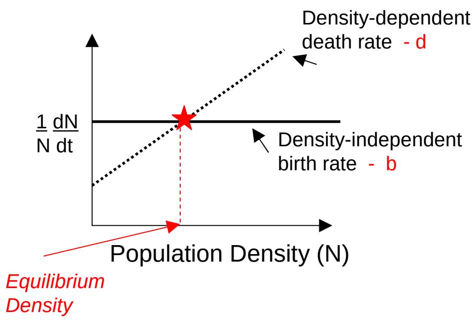
R_0 = Net Replacement = $\sum l_x m_x = 3$

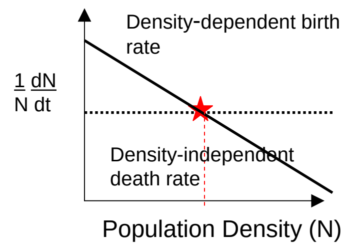
$G \sim (\sum l_x m_x x) / (\sum l_x m_x) = (\sum l_x m_x x) / R_0 = 4/3$ years

Intrinsic Rate of Increase

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

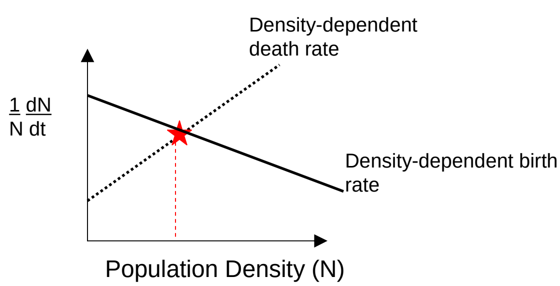
Density-Dependant Factors Regulate Population Size

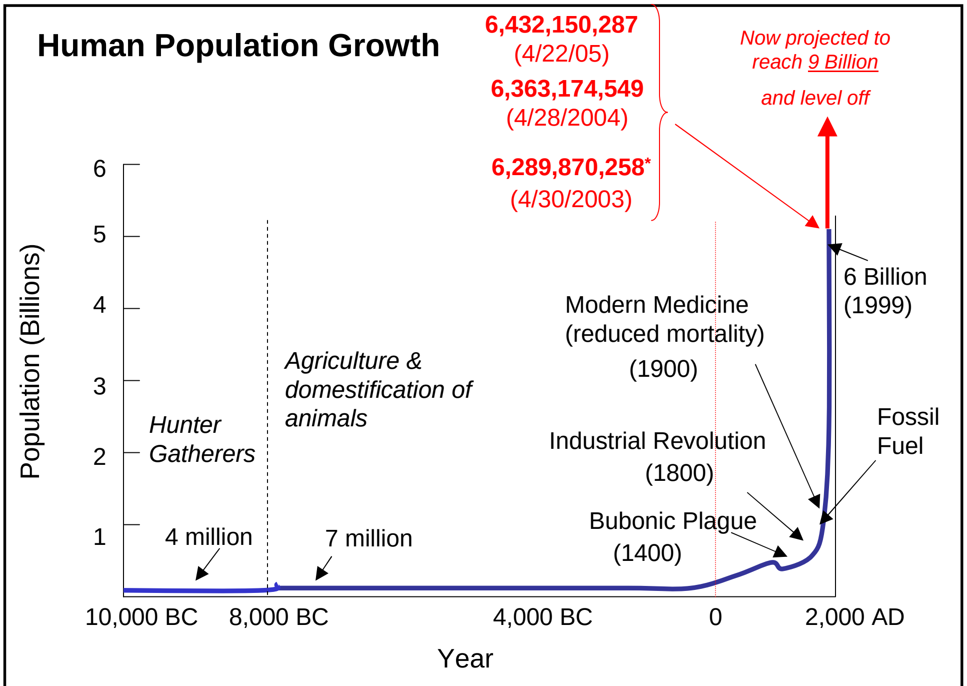




r = b-d

as N↑ r↓
stabilizing





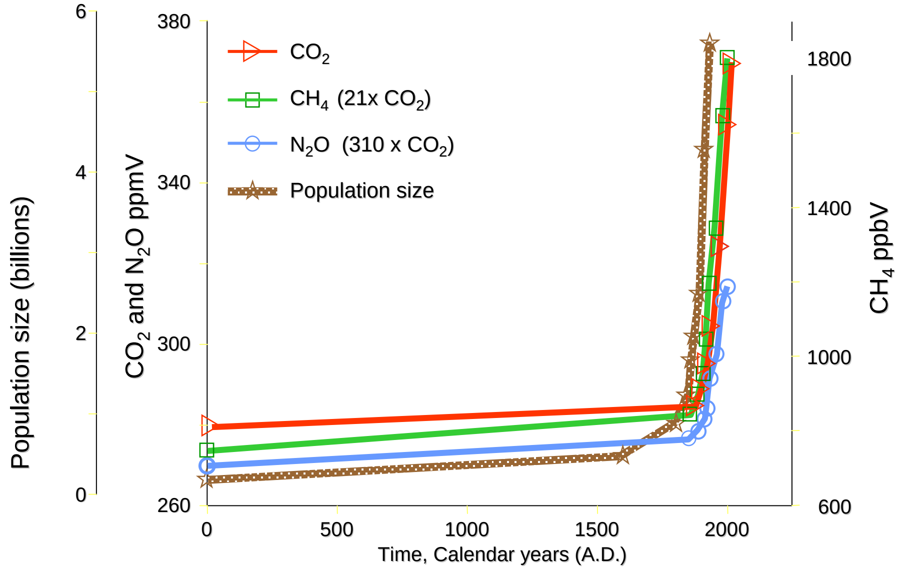
Adapted from: Cohen, "How Many People Can the Earth Support"   http://www.census.gov/main/www/popclock.html

Four "Evolutions" in Human Population Growth

Evolution Driver	Midpoint	Population (billions)	Doubling Time (years) before	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)

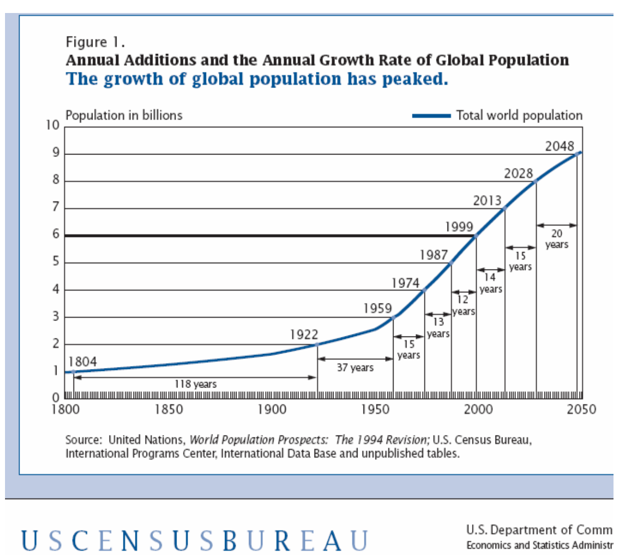
Adapted from: Cohen, "How Many People Can the Earth Support"

and recall from lecture 20......



Falkowski and Tchernov 2004

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



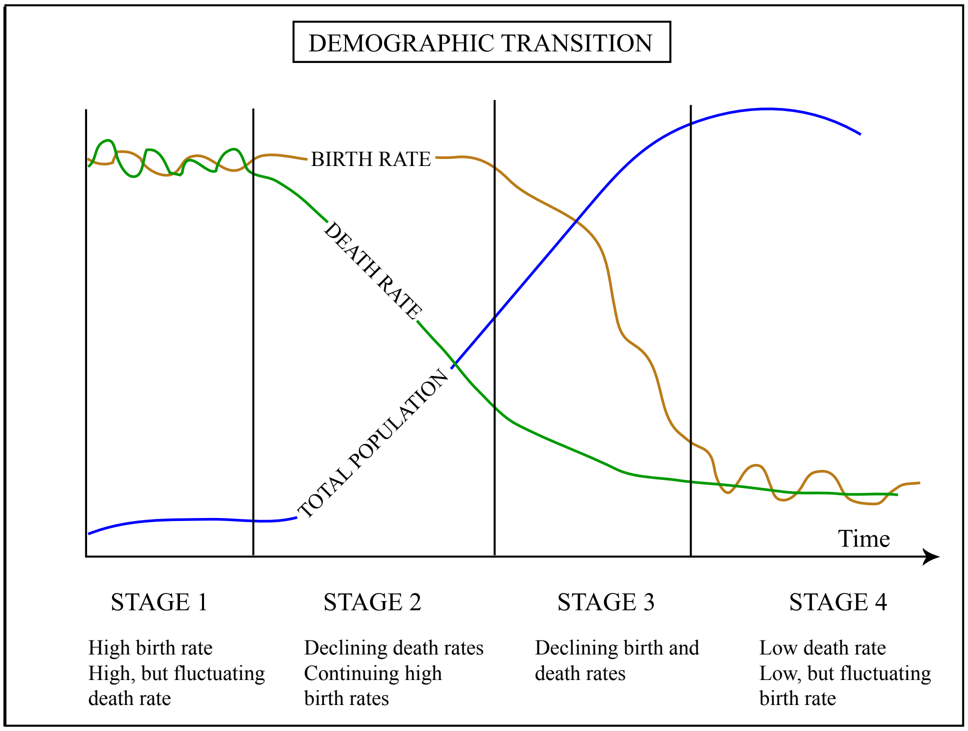


Figure by MIT OCW.