I. History of Demography
II. Demography: attributes of the discipline
III. Data collection and measures
IV. Overview of population-development-environment interactions
V. Simple population projections: the four variable growth model

I. History of Demography:

A. What does demography do?
- counts, interprets, and seeks explanations for aggregate population statistics
- why do we care?

B. Early history -
- Empire - necessitates military service (male population of age x, x+n), taxation
- Census - Sanskrit word for 'assess' or 'tax'

- Biblical quote: On the first day of the second month, in the second year following exodus from Egypt, the Lord spoke to Moses in the wilderness of Sinai, in the Tent of Meeting, saying: "Take a census of the whole Israelite community by the clans of its ancestral houses, listing the names, every male, head by head. You an Aaron shall record them by their groups, from age of twenty years up, all those in Israel who are able to bear arms. Associated with you shall be a man from each tribe, each one the head of his ancestral house.

- Religious organizations recorded various vital events: birth, baptism, confirmation, circumcision, death, disease. Service organization.
> served as ceremonial register; variable resolution.

C. Rise of nation-state -
- 1665 Quebec, 1749 Sweden (compilation of local registry data), 1790 US (apportionment, demography-democracy link)

D. Influential demographers –
- John Graunt - observation on the bills of mortality.
- Edmund Halley - invented life table; cohort analysis. (aside: this mornings astroid)
- Thomas Malthus - first chair in political economy, 'dismal' science, enduring influence.

Moral: discipline arose from very practical needs and pragmatic individuals.

II. Demography: attributes of discipline

A. Population science - merges social & biological aspects (see also LB, more eloquent)

B. Focus on description and explanation of aggregates (a bit of overstatement)

- counter-swing toward individual life histories
- migration example.

C. Key areas of inquiry: size, structure, spatial distribution, and dynamics.

'events': A. Birth, Death, Migration (internal, international)
B. Educational history, marital history, religious affiliation history, work history, ... interact with A list.

D. What is a *natural* population?

Endogamy - reproduction patterns, primarily within a 'local' population, gene pool.

Territoriality - settlement with in a bounded geographic territory and maintain a symbiotic relationship with local environment. Human landscape (language, culture, etc. endogenous to region). Reinforce gene pool. (Demographic assimilation).

Culture - Sociocultural inheritance. Social demography: role for institutions, language, artifacts, innovations.

Moral: human and other animals differ in the constraints imposed by biogenetic inheritance (gene pool) versus cultural inheritance (learning). Demographic laws for human populations are, therefore, tentative.

E. Hazards of aggregation:

1. Ecological fallacy - individual inference based on aggregate analysis. (pp.12)

2. Simpson's paradox - Reversal of prob. statement when confounding variable is not conditioned on.

Overall

	die	survive	P(survive)
Inner city hospital:	11	26	0.70
Suburban hospital:	9	24	0.73

Indigent population:

	Die	Survive		Death rate
City	9	20	0.69	0.314286
Suburb	2	4	0.67	

Non-indigent population:

	Die	Survive		
City	2	6	0.75	0.257143
Suburb	7	20	0.74	

III. Data collection and measures

A. Traditional/non-governmental (church records, proprietary records from businesses or universities)

B. Official Statistics: Census/Registration
- International: UN Fund for Population Activity, resolution 1985/8
- National census counts
  > survey data (U.S. Census, NCHS, INS) <**911** bombings and feedback.>
  > registry data (vital events)

Sample:
** Data Collection **
Are you male or female?
At what age do you expect to marry?
How many children would you like to have?
Do you expect to have a working career?
How many months will you take for maternity leave?
How many children did your birth mother have?

C. Data issues:
1. Comparability of administrative data, registry data, survey data...
2. Samples versus Enumerations:

Census enumeration/sample debacle.
- fear of retribution, neighborhoods,... confirmed undercount.

Bradburn:
"The proposed use of sampling as part of the Census 2000 has led to a fierce political battle. Conventional wisdom has it that the Democratic Party will be favored by sampling because it will result in a higher count of minorities and urban dwellers who are more apt to vote Democratic. Opponents of sampling cite, with alarm, for instance, estimates by unnamed 'experts' that such a result may cause as many as 22 House seats to shift from Republican to Democratic, threatening Republican control of the House. Such estimates, like opposition to census sampling in general, are based on a faulty understanding of the use of sampling... Partisan political advantage has much more to do with the ability to gerrymander legislative districts than it does with whether the Census Bureau uses sampling and statistical methods to produce better counts of the population. **An accurate census serves the best interests of all the population and both political parties**."

IV. Overview of interactions: pop. growth, environment, and economy

Preamble: (Newbold)
- Comments on the world from the viewpoint of child 6 billion
- Will most likely be born into developing world (80% of pop. , 98% of growth)
-What is likely future? Survivorship, famine, war, env. degradation

- pop growth and env. – deforestation, loss of ag/farm land, water pollution
- urbanization / megacities
- extreme interconnectivity among population and other issues: env, health, conflict...

A. Population ~ prosperity

Why 6 billion today, not 100 billion or 100 million?
Complex interactions growth/stagnation, biological/environmental constraints.

B. Strategies of survival:

r-type: fluctuations, env. dependence, short lives, high reproduction.
k-type: equilibrium, slow growth, irregular cycles, large investment in offspring.

Humans are k-type.

C. Principle 1: Divide and multiply.

- observe long-periods or growth or decline, range of growth rates
- how to understand growth, underlying mechanisms

dP = B-D, r=dP/P=b-d (closed)
B, D – 5,10 to 40,50
growth rates, r: -1 to 3.

** Reproductive success: Jacopo Bichi and Domenica Del Buono
(10 couples, 9 offspring to reproductive age)

Moral: aggregate population growth outcome occurs one generation at a time. Ultimately, for a given couple, depends on (1) number of children produced, and (2) intensity of mortality from birth through reproductive age.

D. Principle 2: Growth depends of reproduction and survival

Growth potential = f(reproduction, survival)

Total Fertility Rate (reproduction) - average number of children per woman in absence of mortality. Factors: biological, social, cultural.

Expectation of life at birth (survival) - average duration of life for a birth cohort.
Factors: force of mortality at each age, mortality=f(genes, environment)

1. **Fertility**: TFR=f(freq.of births, portion of fecund period used for reproduction)

>> Frequency = 1/interval (Birth interval)

Birth interval function of:
A. Infertility after birth; breast feeding. Culturally dependent. 3-24 months.

B. Waiting time ovulation - conception, 5-10 months.
C. Length of pregnancy, 9 months
D. Fetal mortality, 1/5 of pregnancies x 10 m wait = 2 months.

Interval: 18-45 months (1.5-3.5 years).

>> Fecund period used for reproduction (cultural): marriage 15-25+, end 40.
15-25 years

>> Min: 15/3.5 = 4.3 children, Max 25/1.5 = 16.7 children ; realistic (5,8)
Rogers/Bergen: 14 children

2. **Mortality**: survivorship function.

Q// How many had friend die that were your age?

Initial cohort (100,000); successive elimination.

Effects proportion of fecund period survived.. Assume 6 TFR in absence of mortality:

e=20, 29% of fecund life (x6) ☞ 1.8
e=50, 71% of fecund life (x6) ☞ 4.2
e=71, 98% of fecund life (x6) ☞ 5.9

If calc yields = 2 then you pay your debt, stable. If calc >2 then growth.

3. **Isogrowth** curves (space of growth)

Fig. 1.8 a, b, c.

Permanence and stability versus instability.

E. Environmental Constraints

- vegetal biomass vs. animal biomass (both precipitation dependenct)
- determines land needs for survival (densities HG: 0.1-1 sq. km.)

- land limits broken by *Agricultural revolution*, more yield per unit land.

Mid-18th century: 40-60 sq.km.
Constraint is energy per unit land (animals/water)

- *Industrial revolution* breaks energy constraint.

Quote:pp26

F. PDE concepts (Pebley)

Four waves of interest:
1. Limited resources - nonrenewable resources, food production
2. By-products of consumption/production
3. Global environmental change (public goods)
Two others: biodiversity; ecology of microorganisms (drug-resistence/emerging diseases)

- Not lack of concern among demographers but taken as given – emphasis on population growth.

Why not more central?
- Other factors more important: social institutions, efficiency, income dist; pop growth not as important.
- Requires expertise outside of demography; working with other scientists. Why not more collaboration. (quote: pp. 380)
- lack of longitudinal data.

Recent research questions:

Greenhouse gases and air pollution:
- macro models
- IPAT accounting identity (env. impact = population x affluence x technology
- missing interactions in IPAT; assumes relationship doesn't test the relationship.
- county level study: relative strength of pop growth on pollution; spillovers, other difficulties.

Land use and deforestation:
- difficulty in obtaining good data (Bilsborrow studies)
- synthesizing multiple data sets (satellite, survey, etc.)

Environmental hazards and migration:
- environmental racism (justice); nasty chemicals are sited in communities with the least political clout.
- deters in-migration but doesn't stimulate out-migration

Other demo-environmental interactions:
spatial distribution: migration, refugee, urbanization – tradeoffs in natural increase and migration. Quote: p382. "Many..."
- local degradation may not be (often won't be) linked to local demographic processes.
Consumption patterns.
Env. change and health.

Ending quote pp. 385.
"Previous research on population and the environment by demographers suggests

> several research strategies that are and are not likely to extend current knowledge. Most previous research is based on either macrosimulations or projections, or on case studies. Both have limitatoins. Macro-simulation and project models depend heavily on assumptions. They are, therefore, most useful as ways to *summarize* empirical knowledge rather than to *generate* it. Case studies of a single village, region, or country can be a useful starting point, but they generally do not provide a solid basis for comparison or inference, given their wide variation in methods and variable measurement, small sample sizes, and selectivity of research sites."
>
> "A few recent studies point the way to a more productive approach. All of these studies test hypotheses based on behavioral models, analyze time series data, ink survey or census data with environmental data, and measure varialbe in a standard and replicable manner."

G. PDE perspective (Panayotou)

- role of behavior / flexibility in systems where human behavior is involved
- household, community, and nation as levels of analysis
- "The relationship between population and environment is neither immutable nor direct. It is mediated by mobility, access to markets, distribution of wealth, institutions, and government policies. Where these factors promote rapid and flexible responses, population growth can be combined with, or even promote, agricultural intensification, industrialization, and technological change culminating in sustainable development."

Simple projections

I. Average annual rate of growth and exponential growth

- concepts: *size* and *growth rate*
- growth rate equals difference between tomorrow's and today's populations divided by today's population
- current global growth rate:

Year	Pop	Growth rate
2000	6,080,141,683	(6.15-6.08)/6.08 = 0.0127
2001	6,157,400,560	(2.34-6.15)/6.15 = 0.0125
2002	6,234,250,387	

A. **Annual vs continuous compounding**

$100 with 10% per year, compounded annually

End of:	Amount:	Formula:
year 1	(1+0.10) 100 = 110	(1+r)P
year 2	(1+0.10) 110 = 121	$(1+r)(1+r)P = (1+r)^2P$

How long until your money doubles? Answer when $(1+r)^n = 2$

$$n = \frac{\ln(2)}{\ln(1+r)}$$, but denominator is Taylor series expansion, $x - \frac{x^2}{2} + \frac{x^3}{3} \ldots$

If the interest is compounded twice a year, greater return..

End of:	Amount:	Formula:
month 6	$(1+\frac{0.10}{2})100 = 105$	$(1+\frac{r}{2})P$
month 12	$(1+\frac{0.10}{2})105 = 110.25$	$(1+\frac{r}{2})(1+\frac{r}{2})P = (1+\frac{r}{2})^2P$

For interest compounded *k* times per year, the end of year balance is..

$$(1+\frac{r}{k})^kP$$

As *k* increases to infinity, the expression yields the continuous compounding expression:

$$\lim_{k\to\infty}(1+\frac{r}{k})^k = e^r$$

after one year, $e^{0.10}100=\$110.50$

after *t* years, $e^{0.10t}100$

B. **Exponential growth**

$P^{(1)}=(1+r)P^{(0)}=e^{r}P^{(0)}$ ... in *t* years ... $P^{(1)}=(1+r)^{t}P^{(0)}=e^{rt}P^{(0)}$

- for small values of *r* both expressions yield similar results

- When will the initial population double?

$$\frac{P^{(t)}}{P^{(0)}}=2=e^{rt}$$

$$t_d=\frac{\ln 2}{r}\approx\frac{0.70}{r}=\frac{70}{100r}$$

- In 2000, population 6.08 billion and growing at rate 0.0127, what will population be in the year 2010?

$e^{0.0127(10)}6.08=6.903$ - or - $6.08(1.0127^{10})=6.898$

II. Fundamental Four-Variable Growth Model

if $P^{(1)}=e^{rt}P^{(0)}$ then given any 3 of the 4 variables one should be ale to calculate the fourth:

i. Given $P^{(t)}$, $P^{(0)}$, and *t*, find *r*
ii. Given $P^{(t)}$, $P^{(0)}$, and *r*, find *t*
iii. Given $P^{(0)}$, *r*, and *t*, find $P^{(t)}$
iv. Given $P^{(t)}$, *r*, and *t*, find $P^{(0)}$