ATTACHMENT G

JOEL COHEN PRESENTATION EXCERPTS

How many people can Earth support?

Human carrying capacity of Earth

How many people do people want on Earth?

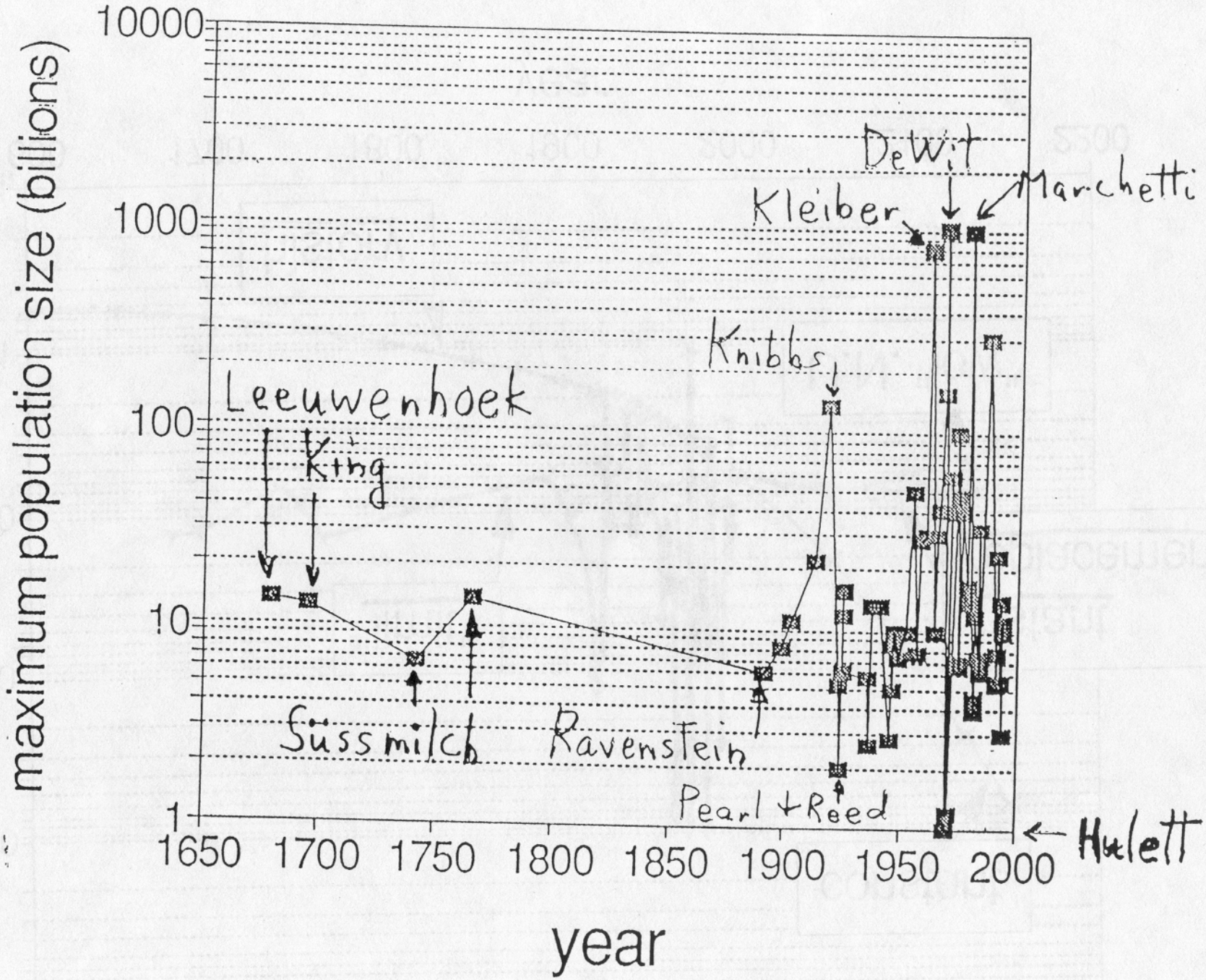
Optimal population

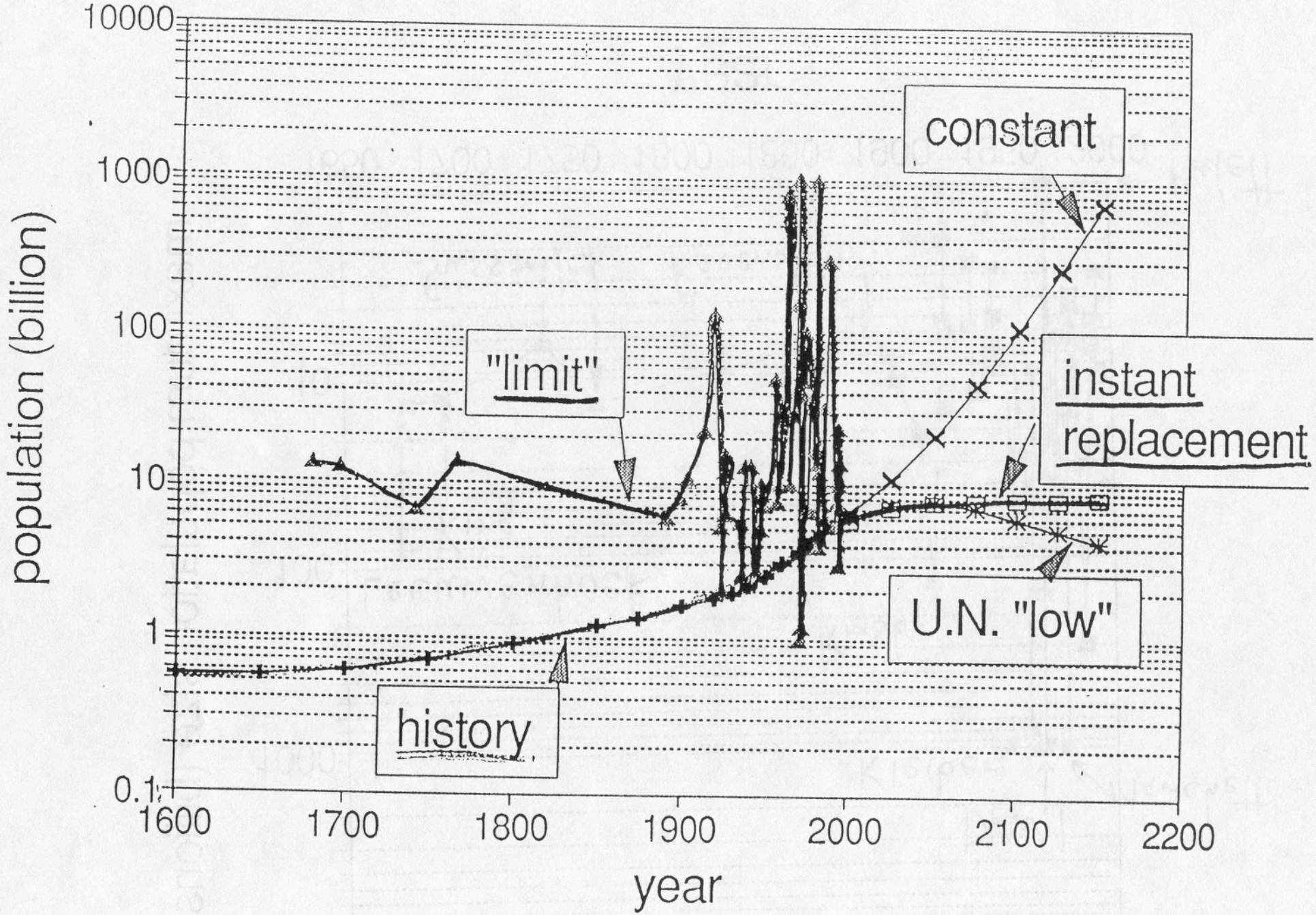
How should human population change now?

Human population growth and development

Agenda 21 (Rio 1992)

"5.23 An assessment should also be made of national population carrying capacity in the context of satisfaction of human needs and sustainable development, and special attention should be given to critical resources, such as water and land, and environmental factors, such as ecosystem health and biodiversity."


maximum population size (billions)
10000
1000
100
10
1
1650
1700
1750
1800
1850
1900
1950
2000
year
Leeuwenhoek
King
Süssmilch
Ravenstein
Knibbs
Pearl + Reed
DeWit
Kleiber
Marchetti
Hulett


10000
1000
100
10
1
0.1
population (billion)
1600
1700
1800
1900
2000
2100
2200
year
constant
"limit"
instant
replacement
U.N. "low"
history

1994 estimates: billions of people

< 3	David Pimentel et al. 0.5 ha farmland per person solar power
2.6 - 10.5	Lester Brown & Hal Kane 2.1 bln t grain harvest (2030) U.S. 800, India 200 kg/y
> 10	Paul Waggoner double area of farmed land 3,000-6,000 kcal/day
10-11	Vaclav Smil eliminate waste & slack new productive inputs
11-44	Scientific Council for the Dutch Government depends on desirable scenario

20th century political estimates

Low limits: urgent to reduce population now.

High limits: population growth and size are no problems.

Methods of estimating human carrying capacity

Assertion

Maximum density (by climatic zone)

Curve fitting: Pearl

Single limiting factor: Knibbs, Penck

$$\text{max. pop.} = \frac{\text{max. global food production}}{\text{min. individual food requirement}}$$

Multiple limiting factors converted to single currency: Clark

$$\text{max. pop.} = \frac{\text{global productive land}}{\text{min. individual land requirement}}$$

Independent limiting factors: Liebig

$$\text{max. pop.} = \text{minimum of} \left\{ \frac{\text{global food}}{\text{food p.c.}}, \frac{\text{global wood}}{\text{wood p.c.}}, \frac{\text{global water}}{\text{water p.c.}} \right\}$$

Multiple interacting limiting factors: system models

"Limiting factors" for human population?

Brian J. Skinner 1969, geologist, Yale:
"More than any other factor, availability of water determines the ultimate population capacity of a geographic province."

food
land
energy
fresh water
biologically accessible nitrogen
phosphorus
light
soil
space
diseases
waste disposal
nonfuel minerals
forests
biological diversity
climatic change

Concepts of carrying capacity in basic ecology

1. Parameter K in logistic equation

$$\frac{dP(t)}{dt} = rP(t) \times (K - P(t)).$$

2. Population size where birth rate equals death rate

3. Population size where population neither grows nor declines

4. Population size set by Liebig's law of the minimum

Concepts of carrying capacity in applied ecology

Imagine simple food chain of deer grazing on grass.

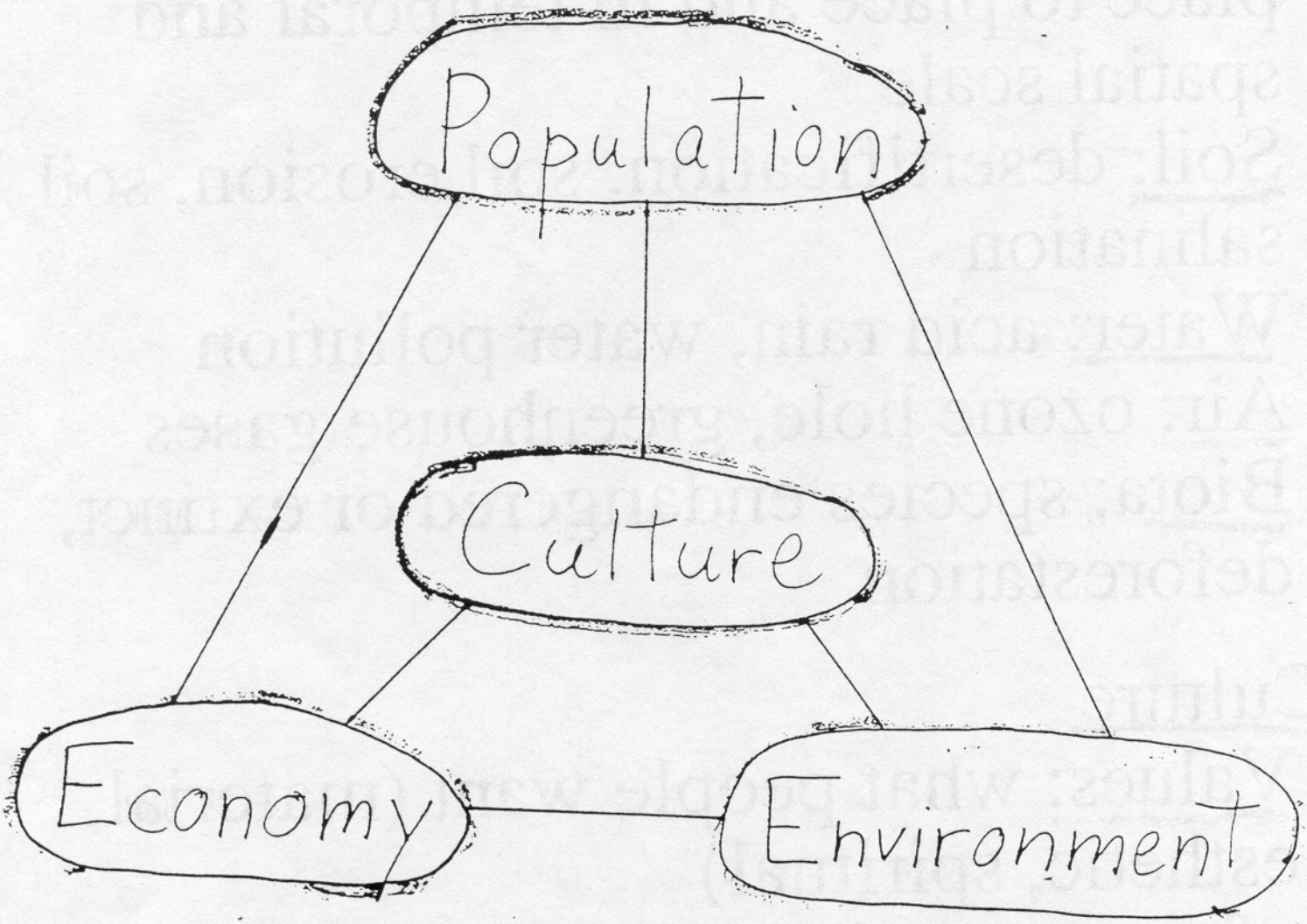
5. Deer population size that maximizes number of deer

6. Deer population size that maximizes yield of deer

7. Deer population size that maximizes stock of grass

8. Size of a harvested population that belongs to a sole owner

9. Population size of an open-access resource


Population
Culture
Economy
Environment

Environmental problems are 1 corner of a 4-cornered pyramid

Ecosystem: Problems differ from place to place and in temporal and spatial scale

Soil: desertification, soil erosion, soil salination

Water: acid rain, water pollution

Air: ozone hole, greenhouse gases

Biota: species endangered or extinct, deforestation

Culture

Values: what people want (material, esthetic, spiritual)

fur coats, whale meat, rhinoceros horns, mahogany furniture

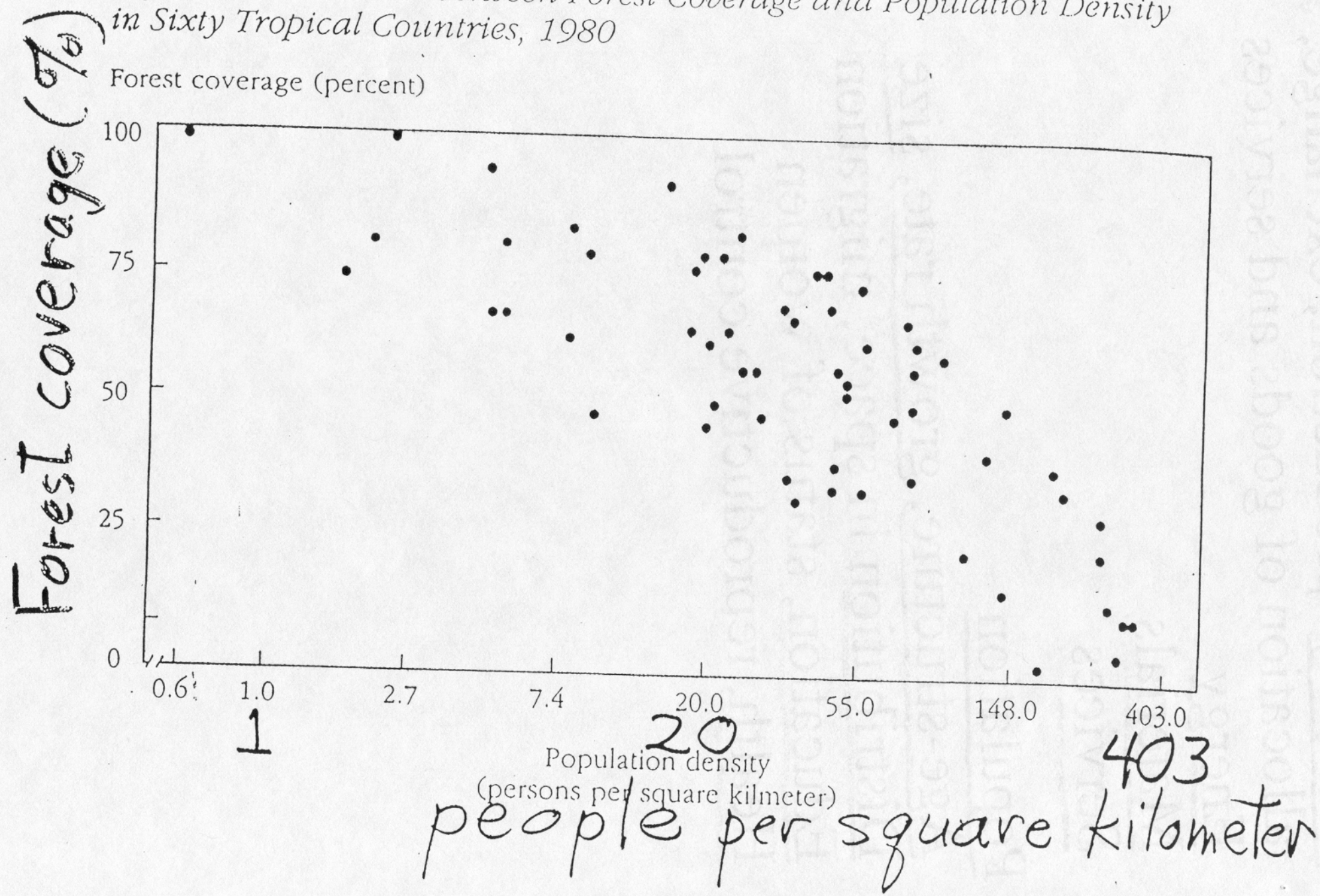
Technology: devices for satisfying wants

Institutions: how people interact

Economy: production, exchange, and allocation of goods and services
Energy
Materials
Services

Population
Age-structure, growth rate, size
Distribution in space, migration
Education, status of women
Health, reproductive control

Figure 6-4. Relation between Forest Coverage and Population Density in Sixty Tropical Countries, 1980



International flows: a network of pyramids around the earth

Ecosystems: acid precipitation, chlorofluorocarbons, radioactive fallout, greenhouse gases, airborne soil (Sahel dust in Florida, Mongolian clay in Hawaii), fish stocks, migratory wildlife, international rivers

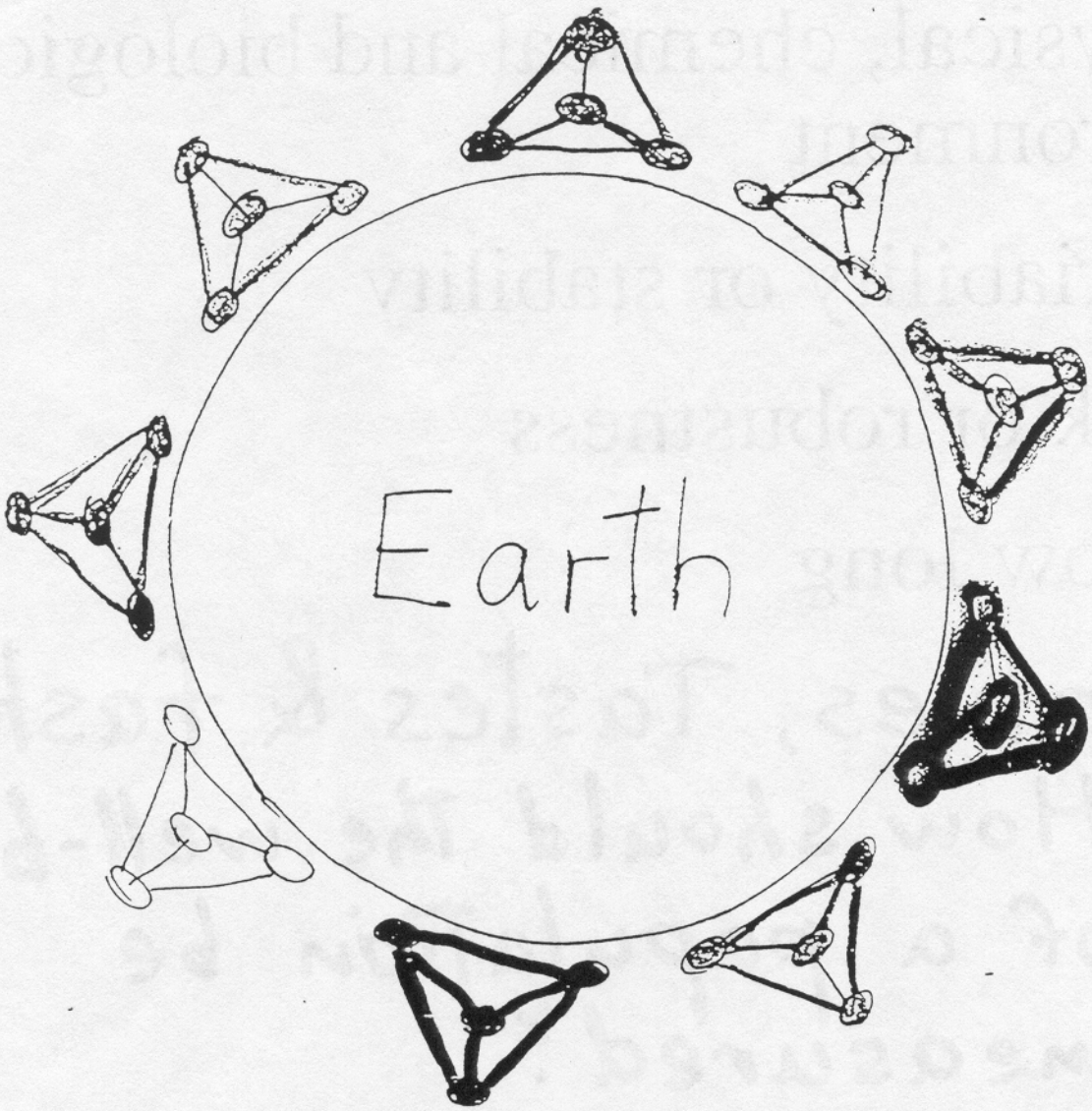
Cultures: jeans, Coca-Cola, movies, news, technology, ideology

Economies: trade in finished product, capital flows, management

Population: migration, infectious diseases

How many people can Earth support?

1. Average level of material well being
(food, fiber, water, housing, industrial output, health, sanitation, energy, education, travel)
2. Distribution of material well being
3. Technology
4. Domestic and international political institutions
(individual freedom, means of resolving conflicts, procedures for change)
5. Domestic and international economic arrangements
(incentives, production, trade, regulation)


Earth

6. Domestic and international demographic arrangements (marriage and family, birth, death, migration, age structure)

7. Physical, chemical and biological environment

8. Variability or stability

9. Risk or robustness

10. How long

11. Values, Tastes & fashion

How should the well-being of a population be measured?

Average

Minimum

Total

No number answers the question: "How many people can the Earth support?"

Human choices interact with natural constraints.

Natural systems are unpredictable

- our ignorance
- (possibly) inherent unpredictability.

Future human choices are unpredictable.

Numerical estimates of human carrying capacity are *indicators conditional* on choices and natural dynamics.

Countries & regions interact.

Sources

How Many People Can the Earth Support?
W. W. Norton & Co., New York, 1995
Tel 1-800-233-4830

Population growth and the Earth's human carrying capacity.
Science volume 269, pages 341-346, 21 July 1995

Summary

The past
- Rapid population growth
- Economic growth & disparities
- Increasing environmental impact
- Increasing contact of cultures

1995: 5.7 billion people
- 43 years to double

The future? (1992 U.N. projections)
- 7.6-9.4 billion by 2025
- 7.8-12.5 billion by 2050

How many people can Earth support?
- Natural constraints
- Human choices

Actions
- Bigger pie
- Fewer forks
- Better manners