Human Population 2017

Lecture 11
building a new World model...
Questions?
MARCH FOR SCIENCE
EARTH DAY
APRIL 22, 2017
#marchforscience
UN Projections of World Population Under Three Fertility Assumptions

- High: Red line
- Medium: Blue line
- Low: Green line

- 1950: 2.5 billion
- 2000: 6.1 billion
- 2025: 8.1 billion
- 2075: 10.1 billion
- 2100: 15.8 billion

Fertility assumption: high, medium, low
People/Nature model

What we are modeling...

...Exponential growth

...Biocapacity

...Ecological footprint

...\( I = PAT \)
People model

What did we learn?

Unstable!!
Regional population growth in Europe in 10,000 BCE

14C dating. Sampling density was assumed to mirror population density.

Superposed on exponential growth are numerous boom/bust events on subcentury and multicentury timescales.

Nature model

Sensitivity to Impact

Note *bimodal distribution*. Why is it bimodal?

What did we learn?
People/Nature model

What did we learn?

- Human impact on the environment is modeled as \( I = PAT \)
- Conservation is modeled as the fraction of [eco capital] made unavailable for consumption.
- Technology is the ecological cost of consuming one gha-worth.
- Rationing is parceling out what is available, if there is not enough.
This future crisis may be the direct result of increasing the human population beyond the carrying capacity of the environment. In other words, the higher the ceiling, the more serious the crash. Robson (1981) suggested that famines do not occur divorced from intensive agricultural production.
Better to stop growing early rather than late?
Sensitivity testing of the variable Conserve

Conserve 0.01, collapse completely.
Conserve 0.99, mild oscillation.
Why?
Again, the data overwhelmingly establishes that increasing the amount of food available to the population of any species leads to an increase in the population of that species and a decrease in the amount of food leads to a decrease in the size of the affected population (Caceres et al., 1994; McKillup and McKillup, 1994; Angerbjorn et al., 1991; Wayne et al., 1991; Bomford, 1987)
Food limitations to growth

\[
\mu = \frac{\mu_{\text{max}}}{\sum_n \left(1 + \frac{k_n}{x_n} \right)} + \varepsilon, \quad n \in \{C, N, P, U\}
\]  \hspace{1cm} (5)

Yeast

Growth rate is attenuated by nutrient deficiency.

Food limitations to growth

Infant mortality rate increases with nutrient deficiency.
Intraspecific strife increases with increased population density.


Do humans behave like mice?
Infant mortality increases replacement value

- As infant mortality increases, the number of children reaching child bearing age goes down as a fraction of births. Increased replacement value.

```r
HDI <- [HDI]
TFR <- -8.2918*HDI + 8.9601
## TFR from HDI is modeled as a line
maom <- 25
## median age of mother
m <- 2.0
rv <- 2 + (1-[HDI])*m
## replacement value is modeled as an inverse function of HDI
## to model increased infant mortality in places with low
## development index. Note since HDI is a linear function
## of ecological footprint, rv models increase infant mortality
## with decreased resources (food).
br <- (TFR/rv)/maom
## birth rate from TFR. Total fertility over replacement is the
## growth rate over the median age of the mother. Dividing
## by median age of mother gives the annual birth rate.
return br
```
Infant mortality increases replacement value

Simulation using \( rv \leftarrow 2 + (1-[\text{HDI}])^2 \)
Equation for death rate as a function of EF?
Extensions?

Part 1. **Infant mortality.** This is the percentage of births that do not reach age 1 year. Since infants consume relatively little for a short time, they should not contribute to [Impact], therefore infant mortality should be modeled as an increase in the replacement value, which affects birth rate. Infant mortality is important because the vast majority of the victims of famine are infants.

Part 2. **Inequality.** This is a measure of the fairness of the distribution of resources. High inequality means more resources (Affluence) goes to fewer people. It would be a factor that depends on [rationing], and which links to [HDI]. Inequality is important because it is known to increase under times of strife.

Part 3. **Non-renewables.** This is a stock measured in gha, with no in flow and one out flow to [Ecological Capital]. Non-renewable energy and material sources substitute for renewable resources, so they can be modeled as the same quantity. But non-renewables are not part of Biocapacity, and when they run out, then [Ecological Capital] is drawn down.
Debate prep