7 minute science

Questions

Lecture on Carrying capacity and Gini

Modeling
Farm is to carbon fixation
as
Chemostat is to chemical reaction.

i.e. optimized for biocapacity
Carrying capacity dynamics

No overshoot, carrying capacity remains constant.

Overshoot, correction, growth, overshoot, correction, growth.

Effect of improving technology is a blunted impact, resulting in slower, shallower cycling, since the same Population has a lower Impact.

Given: Overshoot results from growth, limits and delays.

∴ More technology leads to less overshoot, less serious boom/bust given the same Limits and Delay, since Impact growth is slower.
• What is the difference between increasing **Biocapacity** and decreasing the **Technology** factor?

• NOTE: Decreasing the Tech factor means **improving technology**.

• Given: I=PAT

• Given: Maximum B = maximum sustainable I = carrying capacity

• ∴ Maximum P is proportional to maximum B and inversely proportional to T and A. \( P_{\text{max}} = \frac{B_{\text{max}}}{AT} \)

• ∴ Consuming less (A) or improving technology (T) increases carrying capacity.

• ∴ No need to model an additional variable called carrying capacity. Instead model Technology and Affluence.
The model

Factors that modify instantaneous carrying capacity

"Correction"

Instantaneous carrying capacity

Delay. Because we don't see [biocapacity], we only see [eco capital].
Missing feedbacks?

Given that "necessity is the mother of invention", should we add a feedback loop from [rationing] ("necessity") to [Technology] ("invention")?

Can we learn from history? If so, should we add a feedback loop to [conserve]?

Is there feedback to [delay]?
The Green Revolution — quadruple yields


"Most people still fail to comprehend the magnitude and menace of the ‘Population Monster’"

--Norman Borlaug, father of the “Green Revolution”
Haber & Bosch

Haber process generates ammonia (fertilizer) from nitrogen. Nitrogen is often the limiting nutrient in the soil.

\[
\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3 \quad (\Delta H = -92.4 \text{ kJ/mol})
\]

It is estimated that half of the protein within human beings is made of nitrogen that was originally fixed by this process; the remainder was produced by nitrogen fixing bacteria and archaea.

** F.H. also the “father of chemical warfare” was also responsible for the deaths of thousands from chlorine gas in WW1
Oil is not renewable

We are predicted to be at peak, now.

http://www.peakoil.net/

Food production, heat, transportation all depend largely on oil, a non-renewable resource. Are we spending our savings?
Use of non-renewable water in the US

NASA ASTER image of an approx. 557 mi² area of fields (1443 km²) in Kansas which are watered from the Ogallala aquifer with center pivot irrigation systems.
Center-pivot irrigation is water-efficient

Adjustable length, adjustable flow, dangling sprinklers deliver water close to the ground, evenly. Optimized biocapacity
Use of non-renewable water in the US

The Ogallala aquifer is being slowly drained.
Center-pivot farms in Saudi Arabian desert use "fossil" aquifers that are not replenished at all.
How can this be economical?
Limits to food production

- Arable land -- finite, decreasing yields
- Water -- surface, aquifer, fossil water irrigation
- Fisheries -- predicted to collapse by 2050 (R. Ellis, “Empty Ocean”)
- Climate change -- high temperatures lead to crop failure. (failed pollination, insect dependence)
Timeline of Food

Events that increased carrying capacity
What happened in Venezuela?
Mantenidos

- In poor Latin American countries, in recent history moderately well-off people had “empleadas” to wash clothes and cook. This is no longer common.

- Migrations to the US and other countries has led to an industry of family support from afar.

- People receiving money from the US have become unwilling to work for the low wages, such as of an empleada.

- Influx of dollars from abroad (remittance) is the largest single source of capital in El Salvador, Nicaragua,...

- People supported by family and called “vagos” (bums) or “mantenidos” (kept people).
Remittances

- **Remittance** is money sent from 1st world countries to developing countries by private parties. Totalled $436B in 2014.

- Remittances account for much more than the total amount of governmental aid to some poor countries.

- Main recipients are
  1. India ($70B in 2014),
  2. China ($64B),
  3. Indonesia,
  4. Mexico.

Globality

- Food flows across borders
- Energy flows across borders
- Pollution flows across borders
- Violence and disease flow across borders
- People flow across borders
Are we meta-populations?

Which graph reflects regions of the world?

No, not meta-populations

Maybe some meta-populations

Yes, meta-populations
Modeling regionality

- Is our model **global**? Or **regional**?

- Is food supply a **distribution problem**?

- What is the effect of the world not being a "**mixed pot**"?

  - We need a parameter for **global inequality**!

  - How does inequality affect (a) **resource availability**, (b) **affluence**, (c) **technology**, (d) **conservation**... anything else?

  - How do each of those variables affect death rate, birth rate, etc.

- Feedback: what **causes** inequality?
Gini coefficient

- Measure of inequality in a dataset.
- Invented to describe income inequality.
- Area over Lorenz curve and under the diagonal.
- \(0 \leq G \leq 1\)
- \(G=0\) represents perfect equality
- \(G=1\) represents a perfect inequality.

\[ G = 1 - 2 \int_0^1 L(X) \, dX \]
Trend towards increased Gini
Lorenze curve for world income, by whole countries

World Bank data, $PPP 2012

Countries: Gini=0.48 (N=131)
Gini-quality
Gini-quality

• Gini is a good measure for inequality because
  • It is well defined, objective.
  • It can be relate to Affluence (EF)
  • Historical data is available.
  • Studies are available.
Modeling Gini

• How is Gini directly related to: (if at all)?

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