Human Population 2016
Lecture 3
Overshoot
Every day is...

Bring a Question to Class...

- Question should be based on the reading.

- Tests whether you did the reading!

- If you "read" the assignment and don't have a question, you didn't really "read" the assignment.

- Questions will be taken at the beginning of class

- Part of your grade is how many questions you bring to class.
  \[=10\% \times \frac{\text{# of questions}}{\text{# of reading assignments}}\]

- Questions will be selected pseudo-randomly until done or until question time is exhausted. All questions count towards your grade, whether answered or not.
Are we in overshoot?
Overshooting a turn

Cause: momentum + delay
Consequence: loses race
Overshooting your budget

income = $1000/mo at beginning of month
expenditures at end of month (credit card)
causes: growth versus hard limit.
consequences: debt payments, lifestyle adjustment.
What is overshoot?

• When ecological footprint exceeds the size of the earth.
Ecological Footprint

- **Ecological Footprint**: a measure of the demand populations and activities place on the biosphere in a given year.
  - The amount of land that would be required to provide the natural resources and absorb the waste of a population.
  - A measure of Human appropriation of Earth's surface.
  - Measured in global hectares (gha).

- **Biocapacity (carrying capacity)**: a measure of the amount of biologically productive land and sea area available to provide the ecosystem services that humanity consumes – our ecological budget or Nature’s regenerative capacity.
  - The Earth has a total of biocapacity of 12 billion gha.

hectare

/ˈhektər/
noun

a metric unit of area, equal to 100 ares (2.471 acres or 10,000 square meters).

1 hectare = 100 x 100 m²

1 are = 10 x 10 m²

x 100 =

1 hectare ≈ 2 football fields
Ecological Footprint: it's the size of your personal biosphere.

Biosphere 2, Oracle AZ. A 1.27 hectare materially-closed system

8 people lived in the biosphere, 1991-1993
Inside Biosphere 2
Calculating the Ecological Footprint of production

\[ EF_P = \sum_i \frac{P_i}{Y_{N,i}} \cdot YF_{N,i} \cdot EQF_i \]

- Production (in tons) of commodity \( (i) \) / year, including CO\(_2\)

- Conversion to gha (depends on whether commodity is land, sea, or CO\(_2\))

- Yield factor, relative to world average yields.

- National \( (N) \) average yield for the production of commodity \( (i) \) (or its carbon uptake capacity in cases where \( P \) is CO2), in hectares/ton/year.

Ecological footprint of production, in gha (global hectares). May be national, sub-national, or individual.

Earth has a total of 12 billion gha
**Dynamic Ecological Footprint of production**

Production (in tons) of commodity ($i$) / year, including $\text{CO}_2$:

$$ EF = \sum_i \left( \frac{P_{N,i,j}}{Y_{N,i,j}} \cdot YF_{N,i,j} \cdot IYF_{W,i,j} \cdot EQF_{i,j} \right) $$

- **Intertemporal Yield Factor (depends on the current year $j$)**
- **Conversion to gha (depends on whether commodity is land, sea, or $\text{CO}_2$)**
- **Yield factor, relative to world average yields.**
- **National ($N$) average yield for the production of commodity ($i$) (or its carbon uptake capacity in cases where $P$ is $\text{CO}_2$), in hectares/ton/year.**

Ecological footprint of production, in gha (global hectares). May be national, sub-national, or individual.

Earth has a total of 12 billion gha.
consumption land use matrix

countries, regions, land types, non-overlapping and clearly defined consumption categories, or commodities

Y_{N,i} = how much land of type/region/country N is needed to produce a ton of commodity i.

(24 bu/ac)^{-1}

The calculation of Y_{N,i} considers the climate, land suitability, energy-intensiveness of farming and additives (fertilizer and pesticides) used.

Crop yields easily obtained from USDA.

### All Other Hay Area Harvested, Yield, and Production – States and United States: 2014 and Forecasted August 1, 2015

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</table>

EQF: equivalence factors

- EQF converts areas of different land (use) types to a common unit (gha), which are hectares of global average bioproductivity.

- EQF for crops depend on the "suitability index" of the land.

- EQF for livestock (pasture) land based on hectares required to grow feed required to produce meat.

- EQF for CO₂ (yes, it's treated as a commodity!) are based on average CO₂ absorption per hectare of forest.

- EQF for seafood is based calorie equivalents of beef.
Ecological footprint of consumption

\[ EF_C = EF_P + EF_I - EF_E \]

Note: \textit{total} global Footprint of Production equals \textit{total} global Footprint of Consumption. (Waste is considered "consumption"), because total exports equals total imports.
Calculation of Biocapacity

Carrying capacity. Total available renewable resources.
"[based on] what each hectare would be able to inherently deliver."

\[
BC = \sum_i A_{N,i,j} \cdot YF_{N,i,j} \cdot IYF_{W,i,j} \cdot EQF_{i,j}
\]

\(A_{N,i,j}\) represents the bioproductive area available at the country \((N)\) level, for all commodities \((i)\) in a given year \((j)\).

Other variables, as before.
Typically expressed as \textit{per capita}. 
Relative area, and relative biocapacity
Fig. 1. National Footprint Accounts (NFA) accounting framework.
Carbon Footprint

\[ EF_C = \frac{P_C \cdot (1 - S_{Ocean})}{Y_C} \times EQF \]

\( P_C \) = total world production of CO\(_2\)
\( S_{Ocean} \) = fraction of carbon absorbed by the **worlds oceans**
\( Y_C \) = amount of CO\(_2\) absorbed by **forested land**.

Is \( S_{Ocean} \) really a constant?
Is \( Y_C \) really a constant?
Cartogram of Ecological Footprint per capita
Total EF is greater than Earth's carrying capacity.
Footprint/ Biocapacity per capita

Global hectares per capita

BIOPACILITY = Area x Bioproduction (SUPPLY)

ECOLOGICAL FOOTPRINT = Population x Consumption x Footprint intensity (DEMAND)

Year

© Global Footprint Network, 2011
United States of America

BIOCAPACITY
Biological capacity, the ability of an ecosystem to regenerate useful biological resources and absorb wastes generated by humans such as carbon dioxide emissions from fossil fuel.

ECOLOGICAL FOOTPRINT
A measure of how much biologically productive land and sea area an individual, population or activity requires to produce all the resources it consumes and to absorb its waste.

GLOBAL HECTARE
Both Ecological Footprint and biocapacity results are expressed in global hectares, units of biologically productive land and sea area standardized with world average bioproductivity.
Not all countries demand more resources and services than their ecosystems can provide. Australia, for example, uses half the capacity of Australia but its ecological reserve has been eroding over time.

**BIOCAPACITY**

Biological capacity, the ability of an ecosystem to regenerate useful biological resources and absorb wastes generated by humans such as carbon dioxide emissions from fossil fuel.

**ECOLOGICAL FOOTPRINT**

A measure of how much biologically productive land and sea area an individual, population or activity requires to produce all the resources it consumes and to absorb its waste.

**GLOBAL HECTARE**

Both Ecological Footprint and biocapacity results are expressed in global hectares, units of biologically productive land and sea area standardized with world average bioproductivity.
Ecological Creditors and Debtors in Africa: 1961-2008
Growth in human numbers means growth in human activities.
Growth in consumption, and rate of consumption, through technology

20-row corn harvester.
Growth in consumption, and rate of consumption, through technology

24 m wheat harvester (also threshes)

https://youtu.be/FGokREwBu00
Growth in consumption, and rate of consumption, through technology

Amazing Tree Harvesting Machine - YouTube
https://www.youtube.com/watch?v=WQIbFx4xc-M

- https://youtu.be/WQIbFx4xc-M
Growth in consumption, and rate of consumption, through technology

purse-seine ocean fishing
Summary: ecological footprint

- There are a lot of assumptions and mysteries in calculating the ecological footprint. But...
- We have one.
- We know what makes it go up or down.
- We know there is a global limit, we just don't know exactly what it is.
- We know that limit changes with time and technology
Are we in overshoot?

- Definition of overshoot.
- Ways of measuring Ecological Footprint (EF).
- Calculating Carry Capacity or Biocapacity (BC).
- Region-specific EF, BC.
- Reasons for increased EF, BC.

Not yet discussed

- Nature of growth.
- Feedback mechanisms.
- Consequences of overshoot.
- Policies.
…Socrates, whose love of conversation, no less than the mission imposed upon him by the Oracle, leads him to ask questions of all men, young and old alike, ….

Plato, Republic, The Introduction.
Socrates recognizes the difference between the reasoning and the animal brain.

Socrates:

WELL SAID, CEPHALUS, I REPLIED; BUT AS CONCERNING JUSTICE, WHAT IS IT? -- TO SPEAK THE TRUTH AND TO PAY YOUR DEBTS -- NO MORE THAN THIS? AND EVEN TO THIS ARE THERE NOT EXCEPTIONS? SUPPOSE THAT A FRIEND WHEN IN HIS RIGHT MIND HAS DEPOSITED ARMS WITH ME AND HE ASKS FOR THEM WHEN HE IS NOT IN HIS RIGHT MIND, OUGHT I TO GIVE THEM BACK TO HIM? NO ONE WOULD SAY THAT I OUGHT OR THAT I SHOULD BE RIGHT IN DOING SO, ANY MORE THAN THEY WOULD SAY THAT I OUGHT ALWAYS TO SPEAK THE TRUTH TO ONE WHO IS IN HIS CONDITION.

Republic, Book I

Rights should be accorded those in a right mind.
The lizard brain

human

reason

emotions, heartbeat, breathing, fight or flight.
"To argue with a person who has renounced the use of reason is like administering medicine to the dead."

Thomas Paine
English-American political activist, writer and revolutionary.
Argument: Premises and conclusions

Republic, Book I

Socrates:

But let us consider this further point: Is not he who can best strike a blow in a boxing match or in any kind of fighting best able to ward off a blow?

Polemarchus:

Certainly.

Socrates:

And he who is most skilful in preventing or escaping from a disease is best able to create one?

Polemarchus:

True.

Socrates:

And he is the best guard of a camp who is best able to steal a march upon the enemy?

Polemarchus:

Certainly.

Socrates:

Then he who is a good keeper of anything is also a good thief?

Polemarchus:

That, I suppose, is to be inferred.

Socrates:

Then if the just man is good at keeping money, he is good at stealing it.

Polemarchus:

That is implied in the argument.

We must accept the conclusion if we accept the premises.
Serial Socrates: structured debate

1. Divide into groups of 4 (or 3). Group members are selected randomly. Write group members at top of page.

2. Each group receives a Prompt from the instructor. (add to page)

3. Write a Socratic dialog consisting of yes/no questions, answers that cite sources, and a conclusion. Write as many questions/answers as you can in the time allotted. Use web resources. Number your questions.

4. Present dialog for assessment by the rest of the class. One person plays Socrates, another plays the Student. Student reads the prompt and answers. Socrates reads numbered questions.

5. Remaining students assign scores for Truth, Validity and Completeness

   *Validity* — *Is the conclusion logical?*

   *Truth* — *Is the answer supported by the facts?*

   *Completeness* — *Is it the whole truth?*

6. Discuss. You may abstain (i.e. answer yes or no) after discussion.

7. Proceed to next group, dialog.

8. Finish scoring. Turn in dialogs, names, and scorecards
Serial Socrates: scoring

Each student receives Score.

Score = Group score + Individual score.

Group score = total relevant + total valid

Individual score = For each dialog item, +1 points for correct relevance/validity score, -1 points for incorrect score. No points for abstaining.
Serial Socrates: grading

Each student receives Score.

Grade = Group score + Individual score.

Group score = total relevant + total valid

Individual score = Up to +1 points for each correct relevance/validity score, -1 points for incorrect score. No points for abstaining.
**Socrates:** Is not the purpose of food to keep one from death?

**Student:** Yes, of course, for one certainly dies of famine.

**Socrates:** Is it also true that less food leads to an increased chance of getting ill and subsequently dying, food being the substance that expels the spirits of illness?

**Student:** That is reasonable I suppose. A hungry man is a sick man.

**Socrates:** And would you say that there is a well-defined maximum to the amount of food one can consume?

**Student:** Actually not, because a person may be arbitrarily wasteful in consumption.

**Socrates:** Alright, then would you at least accept that there is a minimum limit to the amount of food required for life, and that the limit is greater than zero?

**Student:** I will accept that.

**Socrates:** And further, would you say that there is a point at which more food does not improve one’s chances of survival, but in fact diminishes it?

**Student:** That depends on whether that food is actually consumed and turned into fat, or simply wasted.

**Socrates:** Then let us say that food consumption consists of two parts, the part consumed and the part wasted, and that mortality reaches a minimum in the dimension of consumption, initially dropping and thereafter increasing, but that food waste is independent of mortality.

**Student:** Given what we have said, I must agree.
Result of a good dialog is a model
Bad dialog

- **Socrates**: Is not the purpose of food to keep one from death?  
  - **Student**: Yes, of course.
- **Socrates**: Is it also true that beans are food?  
  - **Student**: That is reasonable I suppose.
- **Socrates**: And would you say that beans must be well-cooked in order to be consumed?
  - **Student**: Actually, it depends on the bean. Jelly beans do not need cooking.
- **Socrates**: Alright, you know that’s not what I meant.
  - **Student**: Is that a question? Aren’t you supposed to ask a question?
- **Socrates**: And you are supposed to answer, so why are you asking me a question?
  - **Student**: You just asked me a question but I can’t answer with a yes or no.
- **Socrates**: Then let us say that food consumption consists of two parts, the part consumed and the part wasted, and that mortality reaches a minimum in the dimension of consumption, initially dropping and thereafter increasing, but that food waste is independent of mortality.
  - **Student**: Given what we have said, I cannot conclude that.
Logic

• Logic allows us to operate at a "higher level".

• Science assumes logic.

• Science operates at a "higher level".
SS: Question types

• **Definitions** -- questions with automatic 'yes' answers. A 'no' answer begs a *semantic argument*!

• **Assertions** -- questions that associate two things (*A is an example of B*, or *A implies B*), one of which is defined, and one of which moves you closer to your goal. Answer may be 'yes' or 'no', in either case must have supporting data. (Supporting data may have been supplied as part of the question.)

• **Follow-up assertions** -- questions that narrow a general assertion or broaden a narrow assertion.

• **Conclusions** -- questions that ask whether something follows logically.

(D/A/F/C)
SS: Answer types

• **Yes/No [reasons]** Evidence included in the question or in the answer

• **Truth.** 1-10. 1 means "completely false", 10 means "true beyond a shadow of a doubt",

(Y/N) (1-10)
• Form teams of 4

• Choose prompt

• **Write dialogs** (~20 minutes)

• **Present dialog. Score dialog.**

  **Question number, Question Type (d/a/f), Truth (1-10)**

  **Conclusion: Question type "c", Validity (y/n/a), Completeness (1-10)**

  **Type --- Definition, Assertion, Follow-up assertion, Conclusion**

  **Truth — Is the answer well-founded?**

  **Validity -- Is the conclusion logical?**

  **Completeness -- Is the argument solid?**
SS:

- Form groups of 4
<table>
<thead>
<tr>
<th>SS: select prompt</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Humanity is in overshoot.</td>
</tr>
<tr>
<td>• Humanity is not in overshoot.</td>
</tr>
<tr>
<td>• Overshoot is wrong.</td>
</tr>
<tr>
<td>• Overshoot doesn't matter.</td>
</tr>
<tr>
<td>• Population is limited.</td>
</tr>
<tr>
<td>• Population is unlimited.</td>
</tr>
<tr>
<td>• Biocapacity depends on humans.</td>
</tr>
<tr>
<td>• Biocapacity does not depend on humans.</td>
</tr>
</tbody>
</table>

| • Humanity can adapt. |
| • Humanity cannot adapt. |
| • Other species do not matter. |
| • Other species do matter. |
| • Quality of life depends on EF. |
| • Quality of life does not depend on EF. |
| • Carbon Footprint depends on humans. |
| • Carbon Footprint does not depend on humans. |
SS: begin!

Write dialog.
Keep writing until told to stop.
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<thead>
<tr>
<th>group</th>
<th>question#</th>
<th>type</th>
<th>true?</th>
<th>valid?</th>
<th>complete?</th>
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<tr>
<td>Conclusion</td>
<td>C</td>
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<td>(1-10)</td>
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<td>(D/A/F)</td>
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Read dialogs aloud.
Enter your scores for other groups.

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Discussion
Upcoming

• **Lecture 4, Feb 5:** Growth, decay, fertility, systems dynamics, feedback.

• Limits to Growth pp 17-36

• Register for InsightMaker!

• Bring a laptop computer!