THE MILLENNIUM DEVELOPMENT GOALS

- Eradicate extreme poverty and hunger
- Achieve universal primary education
- Promote gender equality and empower women
- Reduce child mortality
- Improve maternal health
- Ensure environmental sustainability
- Combat HIV/AIDS, malaria, and other diseases
- Develop global partnerships for development
Feeding The Next 2.3 Billion Peo

*very conservative estimate
In 2050 Population Stabilizes At 8.6-8.9 billion*

* Global Population Estimates Reduced Because of HIV/AIDS

U.N. projections for 2050 lowered by 278 million due to epidemic

Deaths caused by the HIV/AIDS epidemic will reduce the world’s population by 278 million below what it would have otherwise been in 2050, according to new projections from the U.N. Population Division. In the 2002 revision of the official U.N. population estimates released February 26, HIV/AIDS and a reduced number of projected births are cited as dual factors in a total decline in the revised estimate of 400 million.

Overall, world population is projected to be 8,900 million in 2050 as contrasted with the estimate of 9,300 million issued in a 2000 report.
Forecasting Agriculturally Driven Global Environmental Change

David Tilman,¹* Joseph Fargione,¹ Brian Wolff,¹ Carla D’Antonio,² Andrew Dobson,³ Robert Howarth,⁴ David Schindler,⁵ William H. Schlesinger,⁶ Daniel Simberloff,⁷ Deborah Swackhamer⁸

During the next 50 years, which is likely to be the final period of rapid agricultural expansion, demand for food by a wealthier and 50% larger global population will be a major driver of global environmental change. Should past dependences of the global environmental impacts of agriculture on human population and consumption continue, 10⁹ hectares of natural ecosystems would be converted to agriculture by 2050. This would be accompanied by 2.4- to 2.7-fold increases in nitrogen- and phosphorus-driven eutrophication of terrestrial, freshwater, and near-shore marine ecosystems, and comparable increases in pesticide use. This eutrophication and habitat destruction would cause unprecedented ecosystem simplification, loss of ecosystem services, and species extinctions. Significant scientific advances and regulatory, technological, and policy changes are needed to control the environmental impacts of agricultural expansion.
If global population stabilizes at 8.5 to 10 billion people, the next 50 years may be the final episode of rapid global agricultural expansion. During this period, agriculture has the potential to have massive, irreversible environmental impacts. The minimization of these impacts, while providing sufficient and equitably distributed food, will be a great challenge. Although there are likely to be mechanisms and policies that can reduce, or perhaps reverse, many of the trends that we have identified, these solutions will not be achieved unless far more resources are dedicated to their discovery and implementation.
Land Use And Agriculture
Rondonia, Brazil
And if you think they are the only ones having problems…….

Sustainability of irrigated agriculture in the San Joaquin Valley, California.

The sustainability of irrigated agriculture in many arid and semiarid areas of the world is at risk because of a combination of several interrelated factors, including lack of fresh water, lack of drainage, the presence of high water tables, and salinization of soil and groundwater resources. Nowhere in the United States are these issues more apparent than in the San Joaquin Valley of California. A solid understanding of salinization processes at regional spatial and decadal time scales is required to evaluate the sustainability of irrigated agriculture. A hydro-salinity model was developed to integrate subsurface hydrology with reactive salt transport for a 1,400-km² study area in the San Joaquin Valley. The model was used to reconstruct historical changes in salt storage by irrigated agriculture over the past 60 years. We show that patterns in soil and groundwater salinity were caused by spatial variations in soil hydrology, the change from local groundwater to snowmelt water as the main irrigation water supply, and by occasional droughts. Gypsum dissolution was a critical component of the regional salt balance. Although results show that the total salt input and output were about equal for the past 20 years, the model also predicts salinization of the deeper aquifers, thereby questioning the sustainability of irrigated agriculture.

Annual Global Land Surface Temperature Anomalies

Year

Temperature, C
-0.5 0.0 0.5 1.0

National Climate Data Center
The ice in the Arctic Ocean is melting

Both regional and global climate would be impacted, since summer sea ice currently reflects sunlight out to space, cooling the planet's surface, and minimally warming the planet’s atmosphere.
The albedo of the Earth will change, increasing atmospheric warming at twice the current rate.

Every human being brought into this world is *entitled* to:

- **2.3 liters** of safe drinking water/day
- **2,000 calories** worth of safe food/day

for as long as their genetics will allow!
<table>
<thead>
<tr>
<th>Parasite</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hookworms</td>
<td>740,000,000</td>
</tr>
<tr>
<td>Ascaris lumbricoides</td>
<td>1,472,000,000</td>
</tr>
<tr>
<td>Trichuris trichiura</td>
<td>1,049,000,000</td>
</tr>
</tbody>
</table>
Geohelminths (hookworm, ascaris, trichuris)

Eliminate feces as an environmental contaminant and you effectively control all parasitic diseases acquired by fecal-oral route.

Two approaches, two different outcomes:

United States:
The birth of the outhouse. This single architectural wonder controlled all fecally-transmitted infections: viruses, bacteria, protozoa, and helminths.

Southeast Asia and China:
Ferment feces before using as fertilizer on crops: eliminated hookworm, only.
Population Growth and Poverty
The Impact of Food Production on the Ecological Landscape

- Food 11%
- 47% of common & 26% of toxic water pollution
- 78% of aquatic & 54% of terrestrial habitat alteration
- 21% Common & 13% Toxic air pollution
Fragmentation of Ecosystems

Agriculture
Settlement
Mining
Industrialization
Civil unrest
War
Sources Of Pollution

Non-point Sources:
1. Agricultural*
2. Residential

Point Sources:
1. Industrial
2. Residential

*Largest world-wide source - soil erosion, pesticides, fertilizers, herbicides, heavy metals, animal and human waste, etc.
Estimated Overall Waste from US Agriculture (1999 figures)

1. Topsoil erosion - 1,500 MMT
2. Undigested and un-recycled feedstuffs - 25 MMT
Problem:
How to feed the next 2.3 billion people and at the same time avoid using up all the remaining natural resources.
A Possible Solution: The Vertical Farm
Another kind of vertical farm*

*Again, not exactly what I had in mind.
Vertical Farm (www.verticalfarm.com)

Andrew Kranis
Vertical Farms

Chris Jacobs
Vibrant, successful cities are not only possible but necessary for the health of society and our planet. Urban Ecology plans and designs cities that sustain the people, natural resources, and economy necessary for everyone to thrive.

http://www.urbanecology.org/
Some Advantages Of Vertical Farming

- Year-round crop production; 1 indoor acre = 4-6 outdoor acres
- No weather-related crop failures due to droughts, floods, pests
- **Eliminates agricultural runoff**
- Returns farmland to nature, restoring ecosystem services
- Greatly reduces the incidence of many infectious diseases
- Converts black and gray water into potable water
- Adds energy back to the grid via methane generation
- Dramatically reduces fossil fuel use (no tractors, plows, shipping.)
- Converts abandoned urban properties into food production
- Creates sustainable environments for urban centers
- Creates new employment opportunities
- Cannot go to the moon, Mars, or beyond without one
- Reduces the incidence of armed conflict over natural resources, such as water and land for agriculture
Some Applications of Urban Agriculture

1. Food production
   A. Urban
   B. Relief programs - e.g., Niger, Ethiopia, Sudan, etc.
   C. Military
2. Methane production for generation of electricity
3. Purification of polluted water to drinking water
4. Air purification using buildings skinned out with titanium oxide-coated glass
5. Soil production through remediation of black water
6. Create fresh water from salt water using genetically engineered plants
7. Production of pharmaceutically relevant higher plants (e.g., *Artemisia sp.*)
8. Production of corn/sugar cane/sugar beets for making ethanol
9. Production of decorative plants and “ecological banking” of rare plants
10. Urban nurseries for urban forests - e.g., NYC has 4,000 acres of forest
11. Integrated urban complexes (vertical farms, restaurants, living quarters, parks, etc.)
Advantages Of Vertical Farming
Returns farm land to nature, restoring ecosystem services

Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems

by
Gretchen C. Daily, Susan Alexander, Paul R. Ehrlich, Larry Gould, Jane Lubchenco, Pamela A. Matson,
Harold A. Mooney, Sandra Postel, Stephen H. Schneider, David Tilman, George M. Woodwell
The Impact Of Agriculture On Hardwood Forests

Corn, Cotton, Sorghum
Indiana - 36,420 sq mi
   15 million acres of farmland

Ohio - 44,828 sq mi
   14 million acres of farmland

Iowa - 56,276 sq mi
   26 million acres of farmland

Total = 55 million acres

Carbon sequestration of mature hardwood forest = 1 ton/5 acres

Carbon sequestration = 11 million tons of C/yr

% CO₂ removed from atmosphere/yr = 4%
Restoring ecosystem functions means increasing the biodiversity of a given area.
One small advantage of improving the biod.

**Medicine**

- 118 / 150 prescription drugs used in the United States are based on natural sources (9 / top ten)
  - 74% plants, 18% fungi, 5% bacteria, 3% 1 snake
- The commercial value of pharmaceuticals in the developed nations exceeds $40 billion per year
- ~85% of traditional medicine involves the use of plant extracts (affects 80% of humans)
Results of Medical Ecology class project so far:

1. A single 30 story building one square city block in footprint could easily feed 50,000 people/yr.

2. That building will require 26 million kW hrs of electricity.

3. The same building will generate 56 million kW hrs via methane digestion and capture of solar radiation.

4. Over 40 different kinds of vegetables can be grown indoors.

5. Poultry, fish, crustaceans, and mollusks are easy to raise indoors.

6. Forget beef! Just get over it. Remember BSE and move on!
How It Could Work

Sustainability through re-cycling.
If the rest of nature can do it, so can we!
Methane Production and Oxidation

\[ \text{O}_2 + \text{CH}_4 \rightarrow \text{CO}_2 \]

Water

Soil

CO\(_2\)

O\(_2\) + CH\(_4\)

Organic Matter

CH\(_4\)
Living Machines!

The first step in the Ferris State Living Machine is a 2,000-gallon underground anaerobic septic tank, an oxygen-free environment where solids begin settling out and microbes feed on organic material in the waste.

Next is a closed anoxic or partly aerobic reactor. This 5-foot tall, 5-foot diameter tank creates a steep edge transition between the Living Machines' anaerobic and aerobic ecosystems. Here, denitrifying microorganisms go to work converting dissolved nitrates to nitrogen gas.

Biological treatment of wastewater will work without the steep edge of an anoxic reactor, but at a much slower rate.
Methane Digester
No new technology needed
Online Methane Digester
Deurne, Belgium
Pop. 67,773
How to Proceed:

1. G8s - ante up 2 billion/country
2. Each G8 hosts an equal number of LDCs, to include all LDCs.
3. Each G8 recruits 10 fully funded teams consisting of:
   a. Sanitary engineer - G8 + LDC
   b. Agronomist - G8 + LDC
   c. Microbiologist - G8 + LDC
   d. City planner - G8 + LDC
   e. Materials science engineer - G8
   f. Hydrologist
   g. Architects - G8 + LDC
   h. Construction engineer
   I. Others to be named as the need arises
4. Each team invents vertical farming and shares their results at an international annual meeting.
5. At the end of 5 years, the first vertical farm is constructed.
5. The rest is history in the making, as the G8s give away the vertical farm ideas and patents to the LDCs for use in their own countries, FREE OF CHARGE!!!!!
Who else could fund this program?

The Rockefeller Foundation
The Ford Foundation
Bill and Melinda Gates Foundation
The Pew Charitable Trust
USAID
The Geraldine R. Dodge Foundation

Ted Turner  Ross Perot
Top 10 Drug Companies

1. Johnson & Johnson

2. Merck & Co

3. Novartis

4. Bristol-Myers Squibb Company

5. GlaxoWellcome

6. SmithKline Beecham

7. Roche

8. American Home Products

9. Pfizer

10. Abbott Laboratories

2004 Revenues

- 1. Johnson & Johnson: 22.1 billion
- 2. Merck & Co: 21.0 billion
- 3. Novartis: 18.0 billion
- 4. Bristol-Myers Squibb Company: 15.0 billion
- 5. GlaxoWellcome: 31.0 billion
- 6. SmithKline Beecham: ?
- 7. Roche: 13.0 billion
- 8. American Home Products: ?
- 9. Pfizer: 46.0 billion
- 10. Abbott Laboratories: 11.0 billion
Total - 177.1 billion
At this point, you all must be wondering:

“What has this guy been eating/smoking/injecting?”
Results so far:

A small pile of inedible moon rocks!

New Moon Shots Budget = $24 billion
Total cost to fund vertical farm project = $18 billion
Anticipated result: Unlimited food supply for 8.3 billion people
So, let me get this straight. Despite all these wonderful arguments for staying put and trying to solve the problems of the world, you still want to go in Outer space?

OK, then, ...............
…what did these people eat?
Before we can go where no man has gone before, we will first need to invent vertical farming right here on earth!
Only then can we establish a permanent lunar colony.
... or attempt to live on Mars.
Of course, we may not be welcome there!
Look Whose Looking At Us

Vertical Farm
Recent Visitors
World Map

November 12, 2005  www.verticalfarm.com
The Dawn Of
A New Beginning

(perhaps)
So, *What’s For Dinner?*
Anything You Want
Any Time You Want It
Any place on earth
or in the Universe