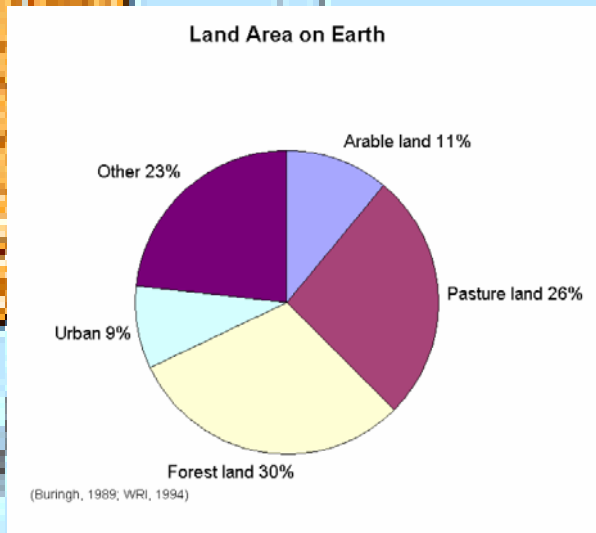
# THE MILLENNIUM DEVELOPMENT GOALS

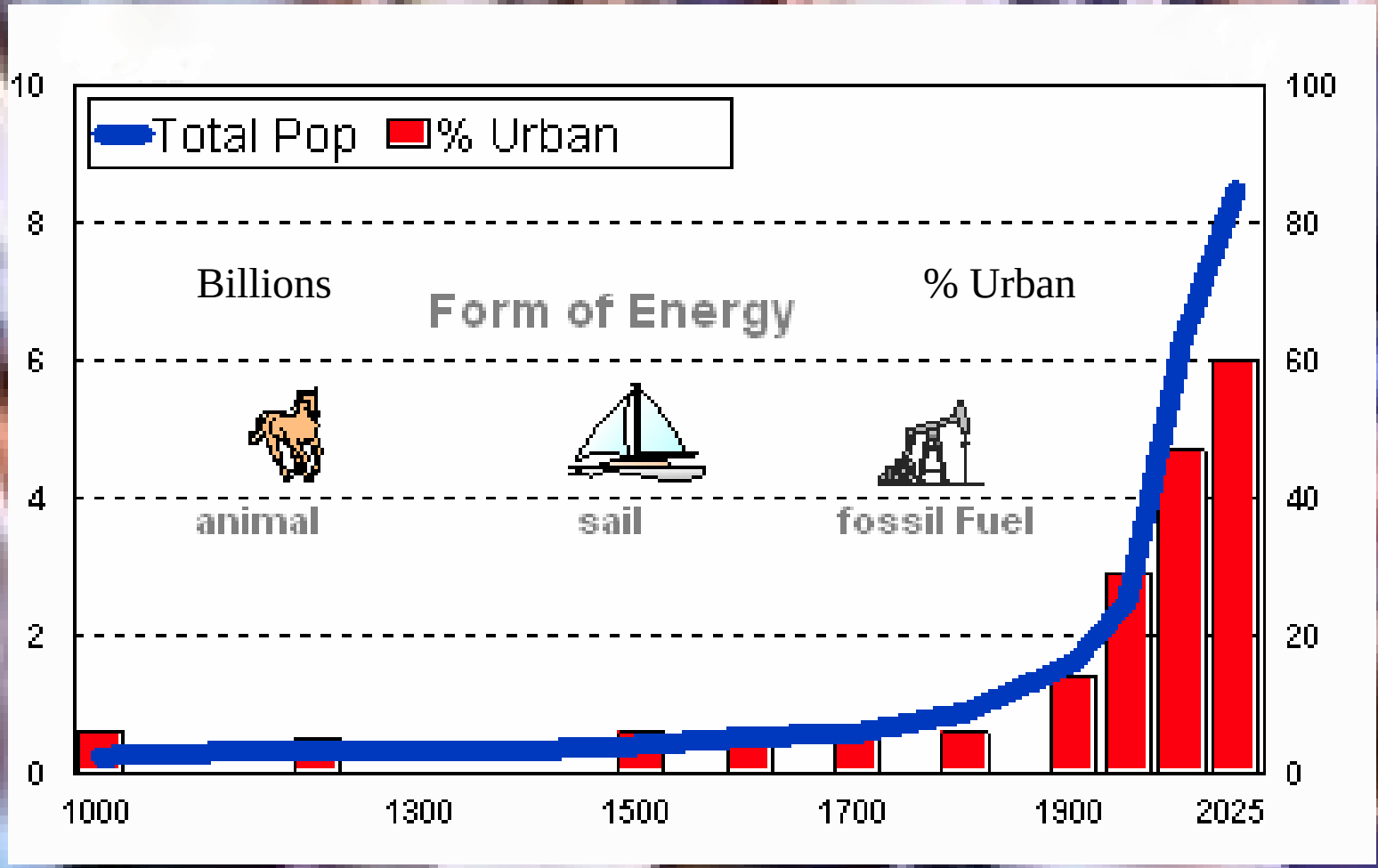
- Eradicate extreme poverty and hunger
- Achieve universal primary education
- Promote gender equality and empower women
- Reduce child mortality
- Improve maternal health
- Ensure environmental sustainability
- Combat HIV/AIDS, malaria, and other diseases
- Develop global partnerships for development

# Feeding The Next 2.3 Billion Peo

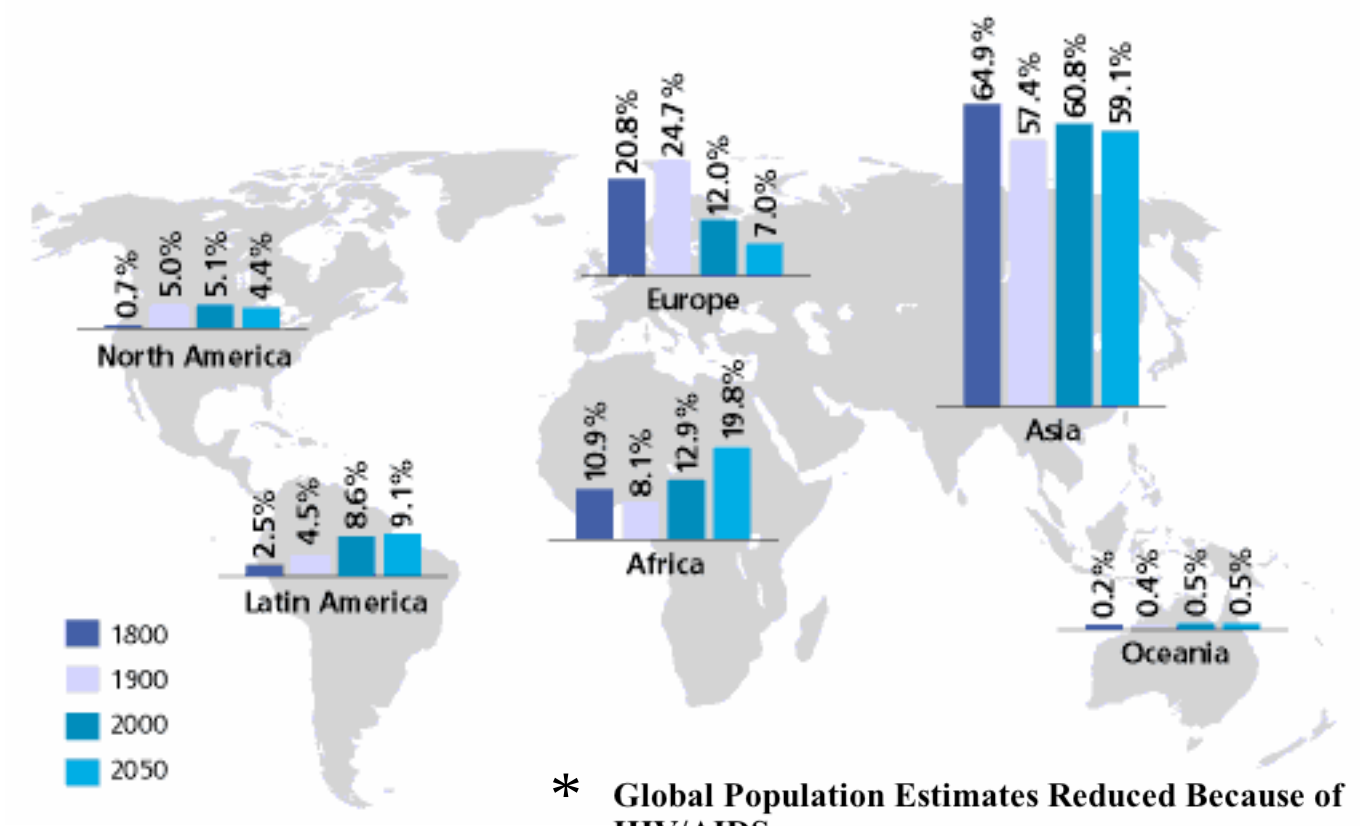

*very conservative estimate

# World Population Density




Total Pop
% Urban
10
8
6
4
2
0
100
80
60
40
20
0
Billions
% Urban
Form of Energy
animal
sail
fossil Fuel
1000
1300
1500
1700
1900
2025

# In 2050 Population Stabilizes At 8.6-8.9 billion*

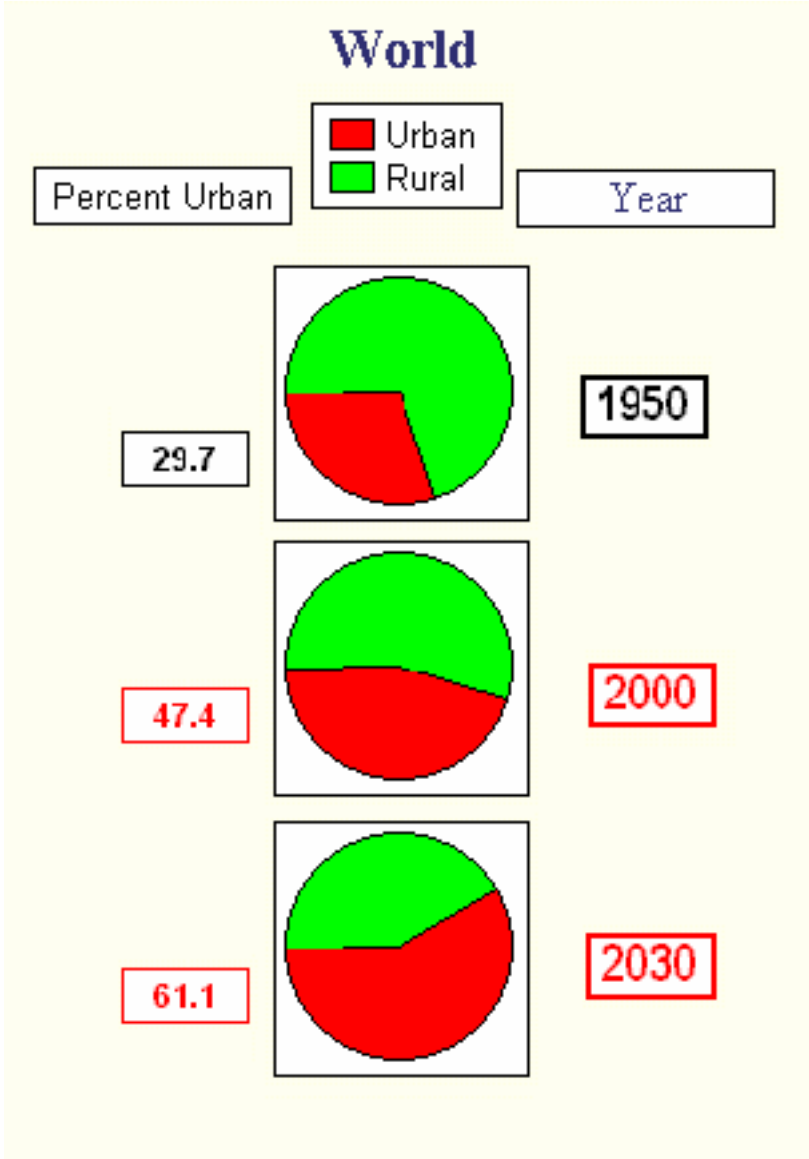



* **Global Population Estimates Reduced Because of HIV/AIDS**

**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.

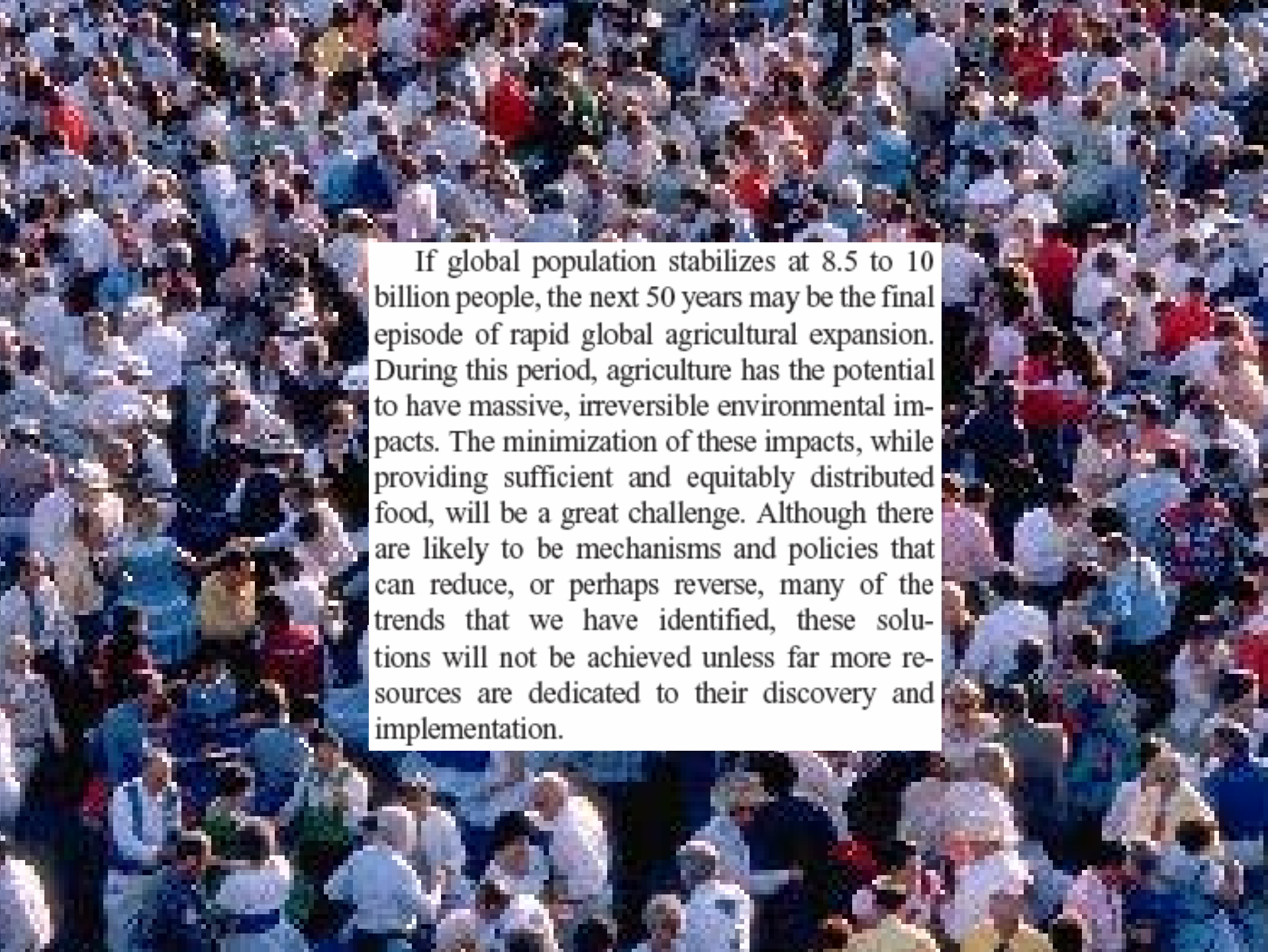

World
Urban
Rural
Percent Urban
Year
29.7
1950
47.4
2000
61.1
2030

# 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 Swackhamer[8]


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, $10^9$ 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.

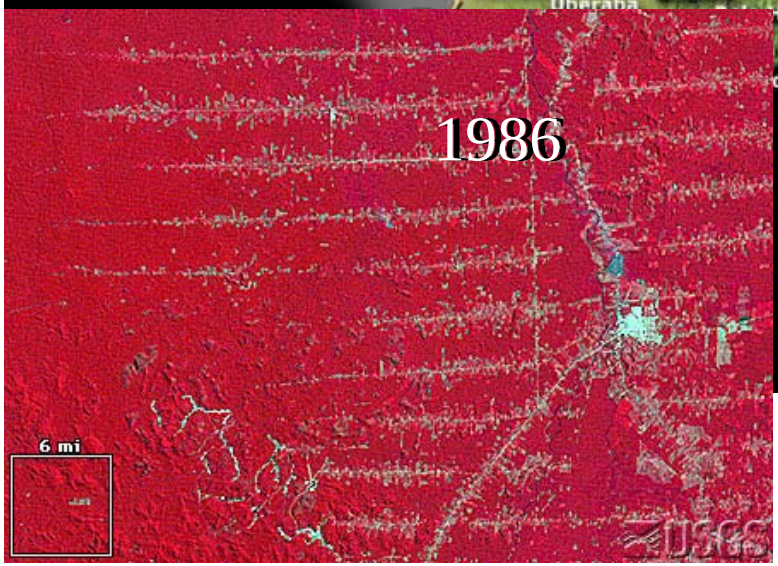
www.sciencemag.org SCIENCE VOL 292 13 APRIL 2001

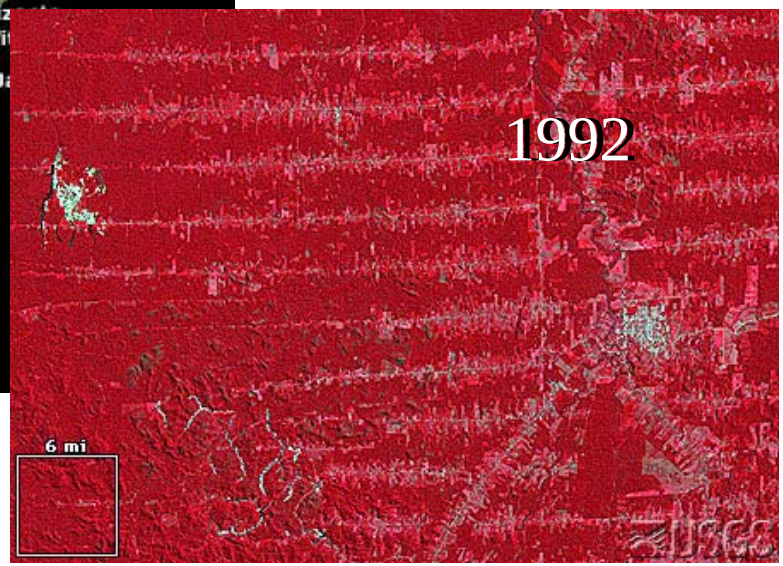


If global population stabilizes at 8.5 to 10 billion people, the next 50 years may be the final episode of rapid global agricultural expansion. During this period, agriculture has the potential to have massive, irreversible environmental impacts. The minimization of these impacts, while providing sufficient 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.

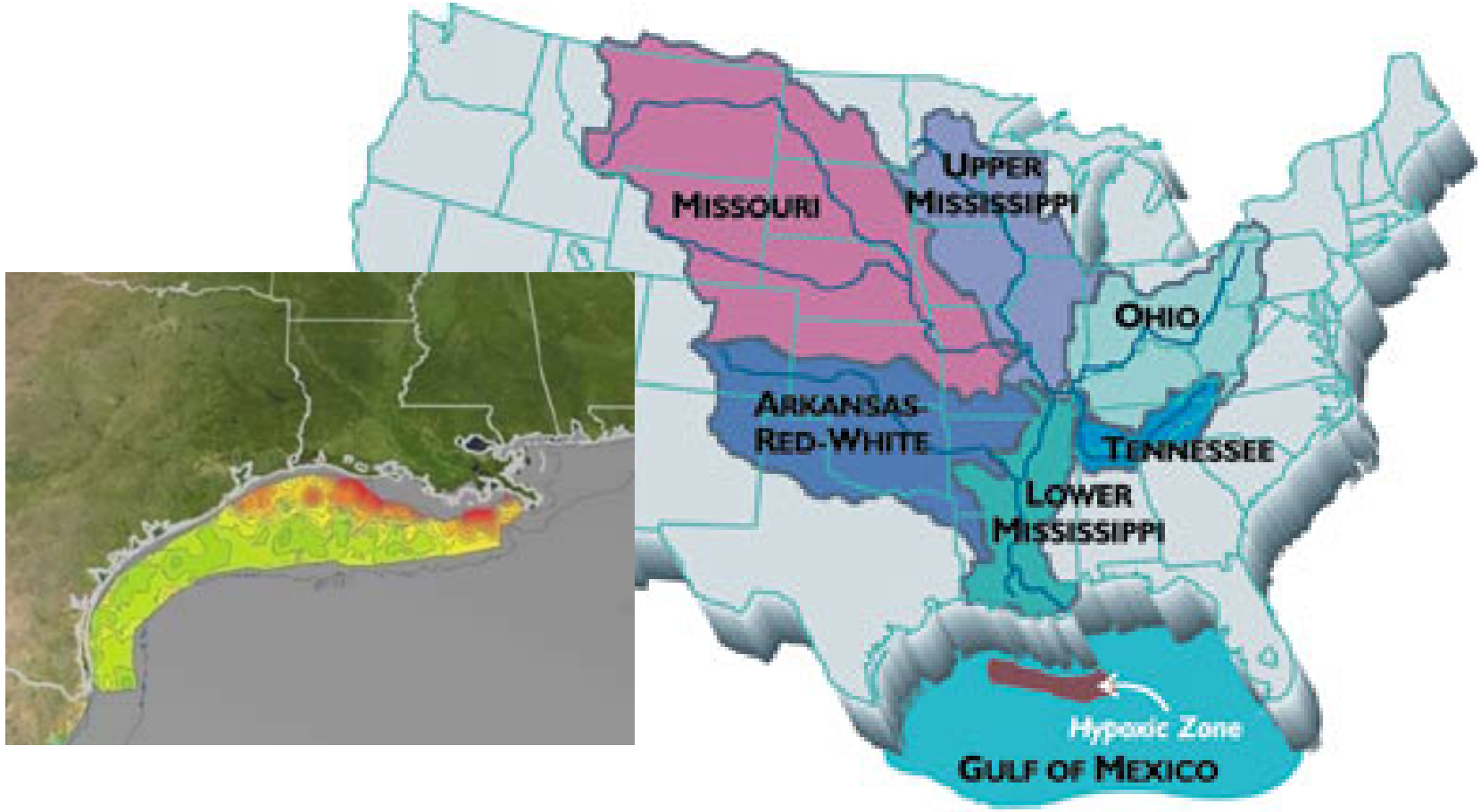
# *Land Use And Agriculture*
## Rondonia, Brazil



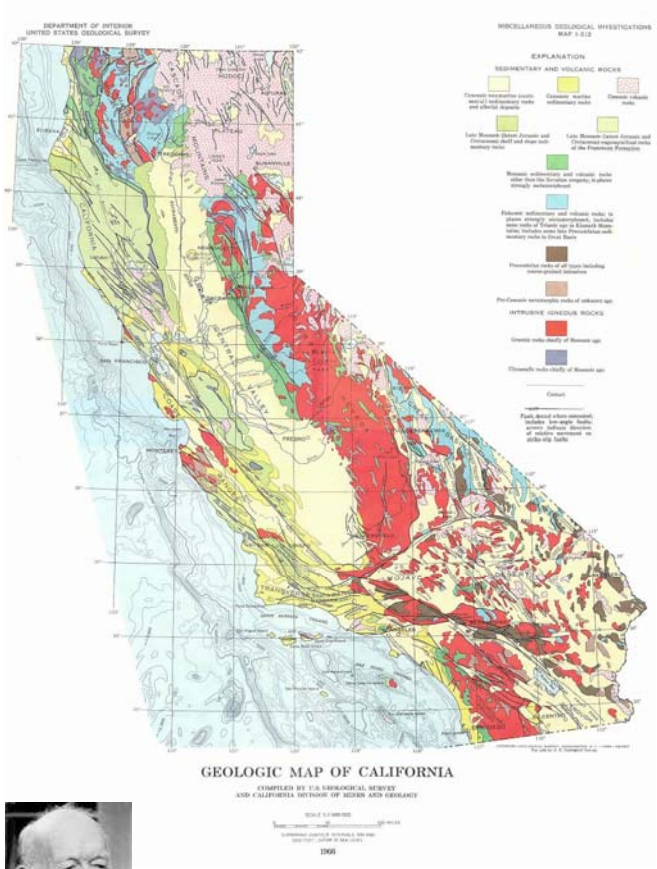


And if you think they are the only ones having problems…….




Gulf “Dead” zone following flood of 1993.
Its still there.



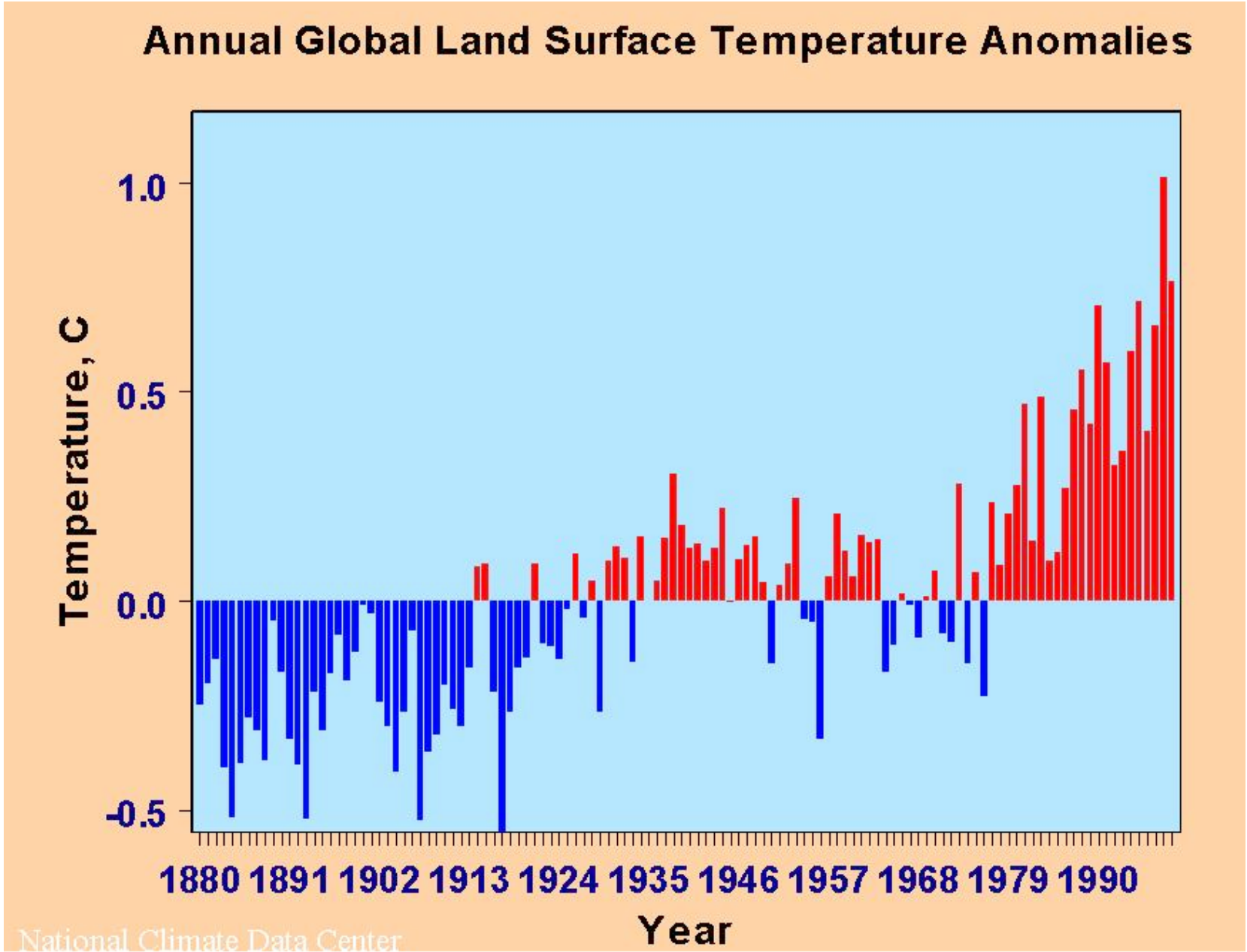

"Think globally, act locally"
R. Dubos

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

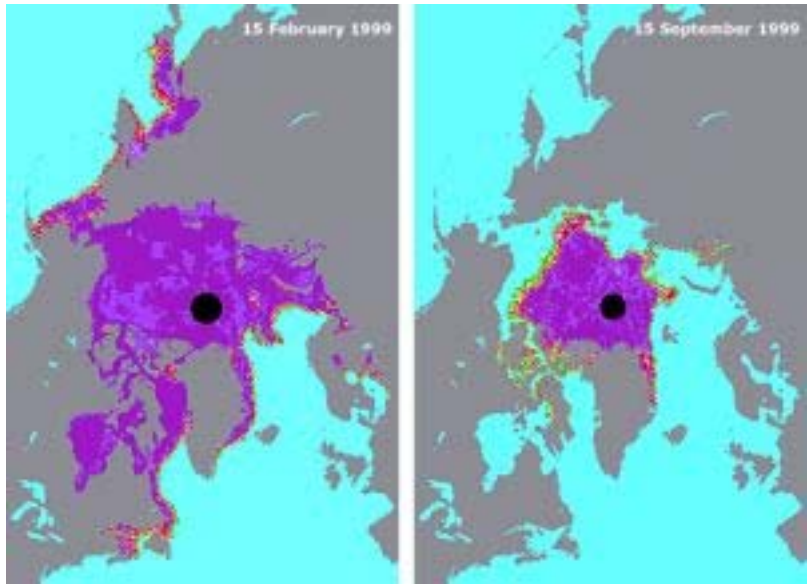
.

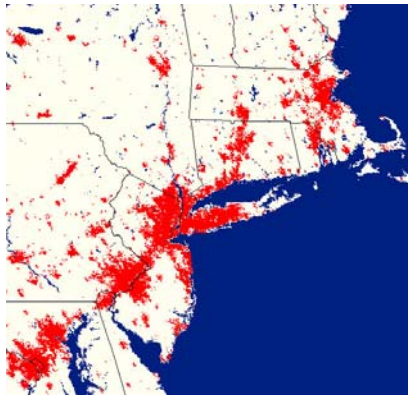
The sustainability of irrigated agriculture in many arid and semiarid areas of the world is at risk because of a combination of several interrelated factors, including lack of fresh water, lack of drainage, the presence of high water tables, and salinization of soil and groundwater resources. Nowhere 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-km(2) 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.

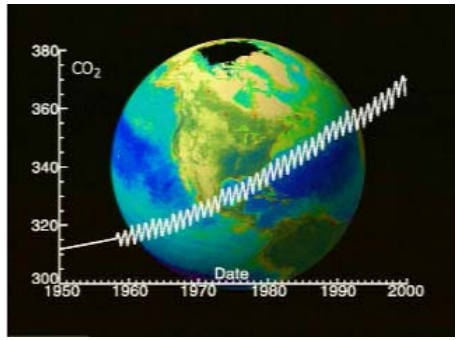
Schoups G, Hopmans JW, Young CA, et al. Proc Natl Acad Sci U S A. 2005 Oct 25;102:15352-6


Annual Global Land Surface Temperature Anomalies
Temperature, C
1.0
0.5
0.0
-0.5
1880 1891 1902 1913 1924 1935 1946 1957 1968 1979 1990
Year
National Climate Data Center

# The ice in the Arctic Ocean is melting

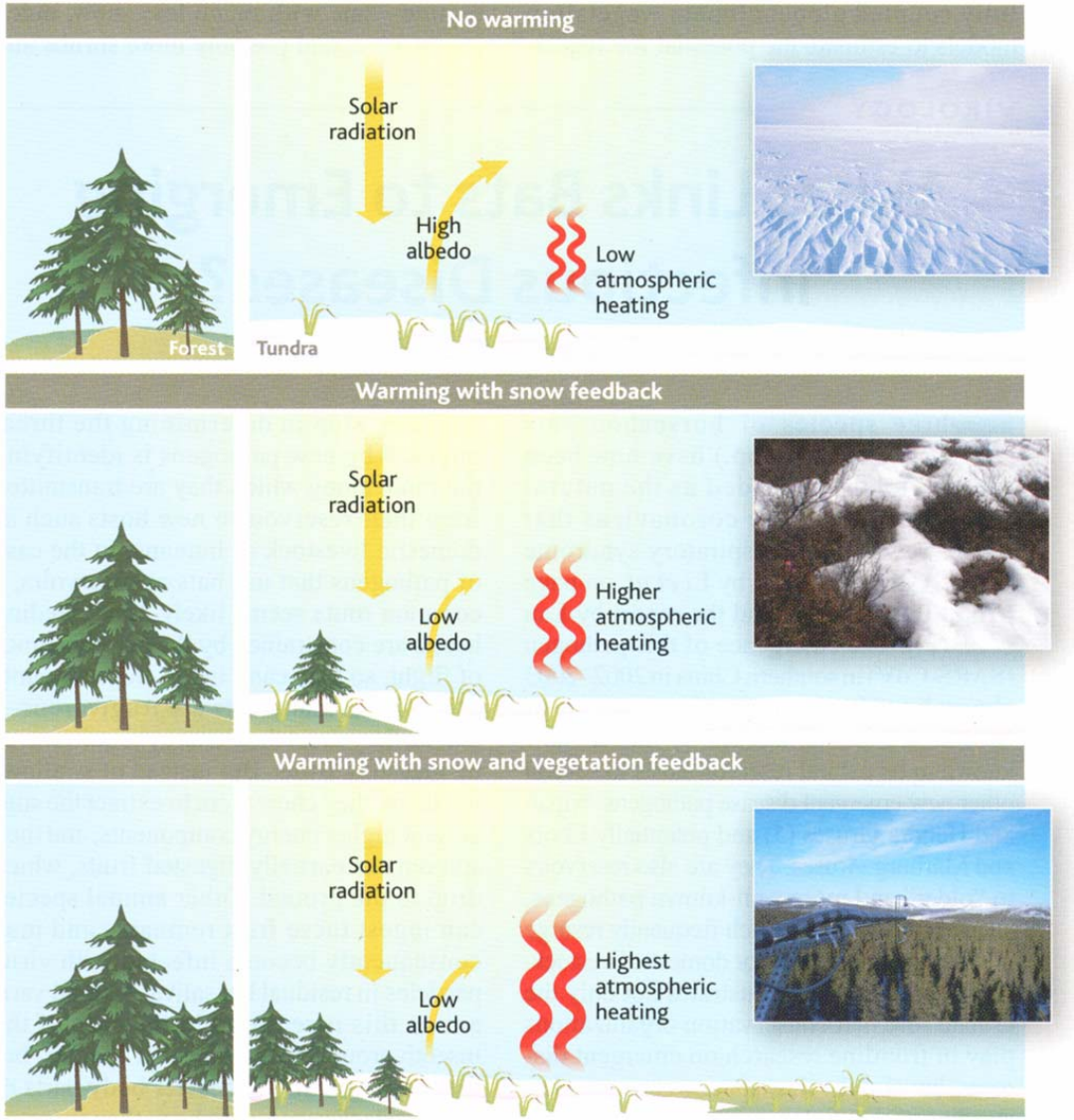






Sources of $CO_2$

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.




**Vicious cycle.** Chapin *et al*. describe positive-feedback mechanisms from changing snow and vegetation cover on the climate of the Arctic. These mechanisms work to amplify global warming in the Arctic by reducing the highly reflective snow cover (**top** and **middle**) and expanding the cover of shrubs and trees (**top** and **bottom**).

The albedo of the Earth will change, increasing atmospheric warming at twice the current rate.

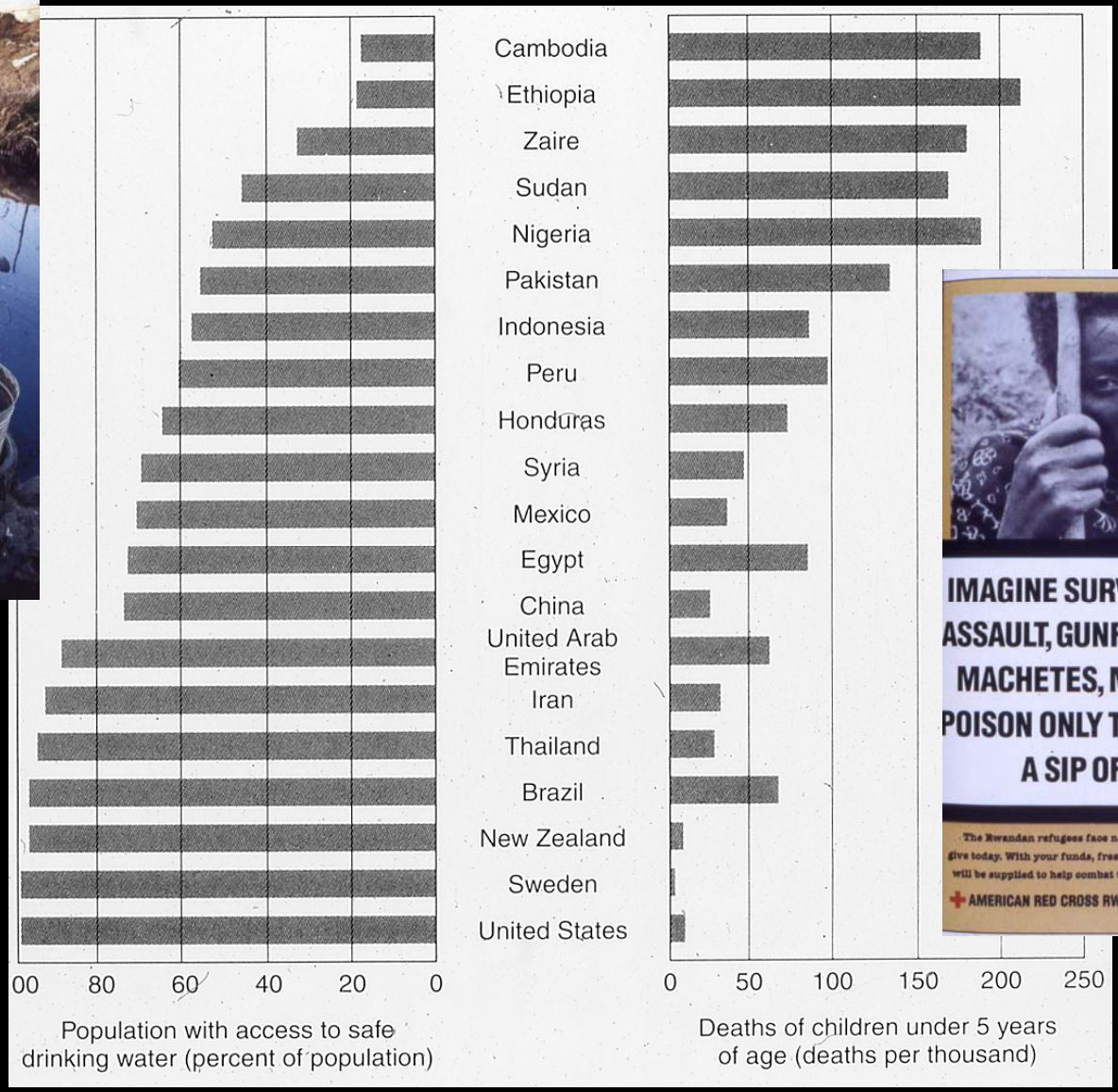
Foley, J. Science Magazine. 2005 Vol. 310: 627-628

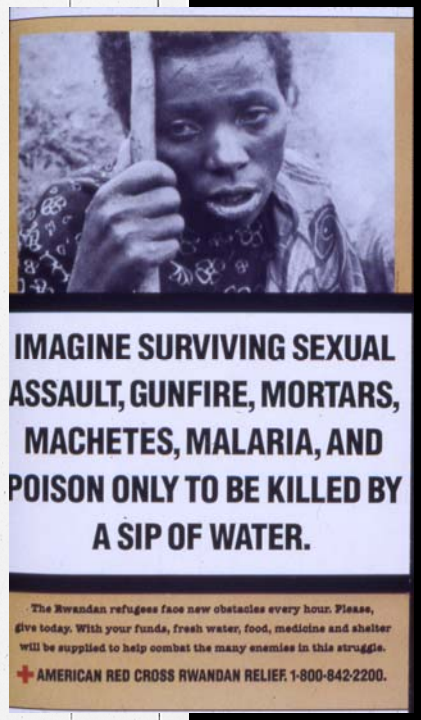
Every human being brought into this world is *entitled* to:

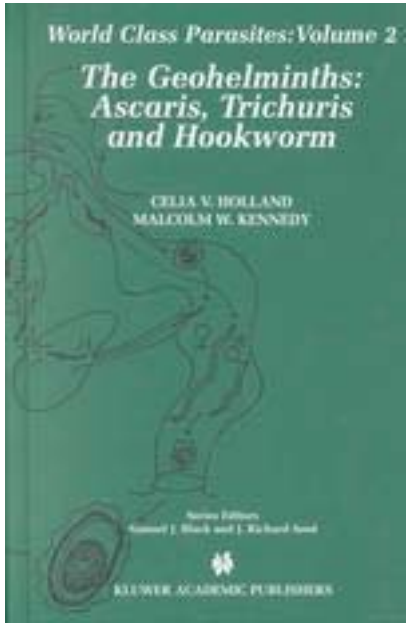
2.3 liters of safe drinking water/day

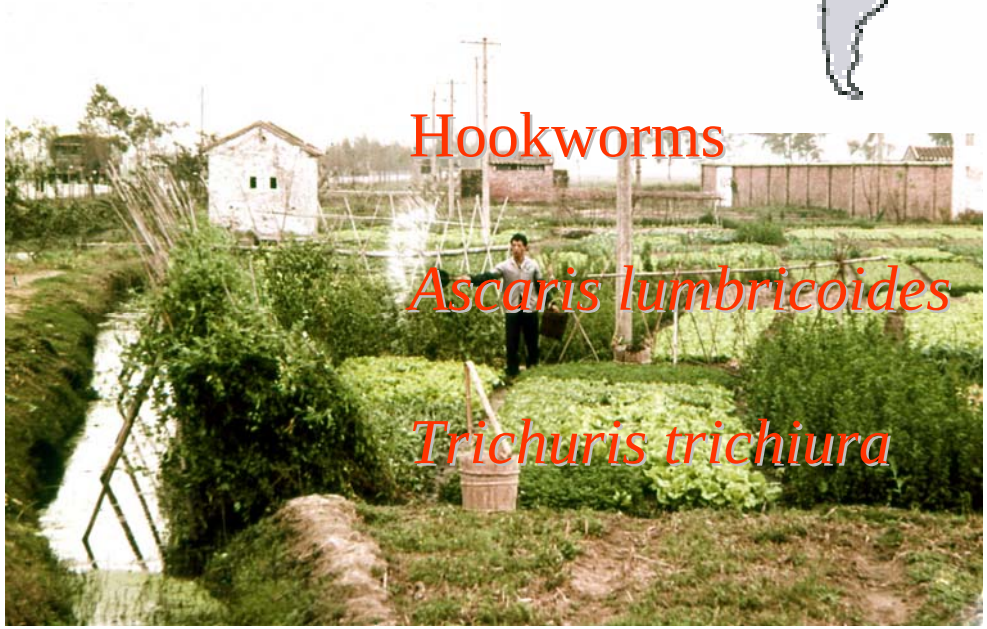
2,000 calories worth of safe food/day

for as long as their genetics will allow!


Cambodia
Ethiopia
Zaire
Sudan
Nigeria
Pakistan
Indonesia
Peru
Honduras
Syria
Mexico
Egypt
China
United Arab Emirates
Iran
Thailand
Brazil
New Zealand
Sweden
United States
00 80 60 40 20 0
Population with access to safe drinking water (percent of population)
0 50 100 150 200 250
Deaths of children under 5 years of age (deaths per thousand)


IMAGINE SURVIVING SEXUAL ASSAULT, GUNFIRE, MORTARS, MACHETES, MALARIA, AND POISON ONLY TO BE KILLED BY A SIP OF WATER.
The Rwandan refugees face new obstacles every hour. Please, give today. With your funds, fresh water, food, medicine and shelter will be supplied to help combat the many enemies in this struggle.
AMERICAN RED CROSS RWANDAN RELIEF. 1-800-842-2200.



Hookworms 740,000,000

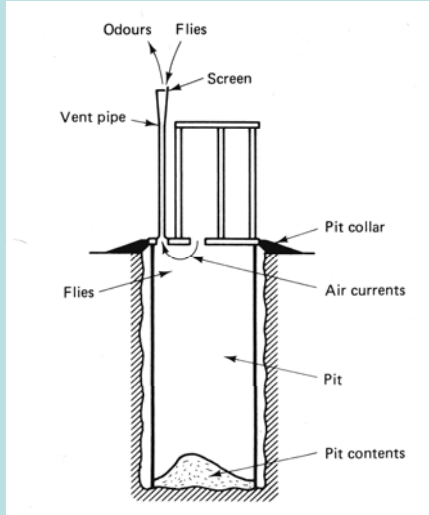
*Ascaris lumbricoides* 1,472,000,000

*Trichuris trichiura* 1,049,000,000

# Geohelminths (hookworm, ascaris, trichuris)

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

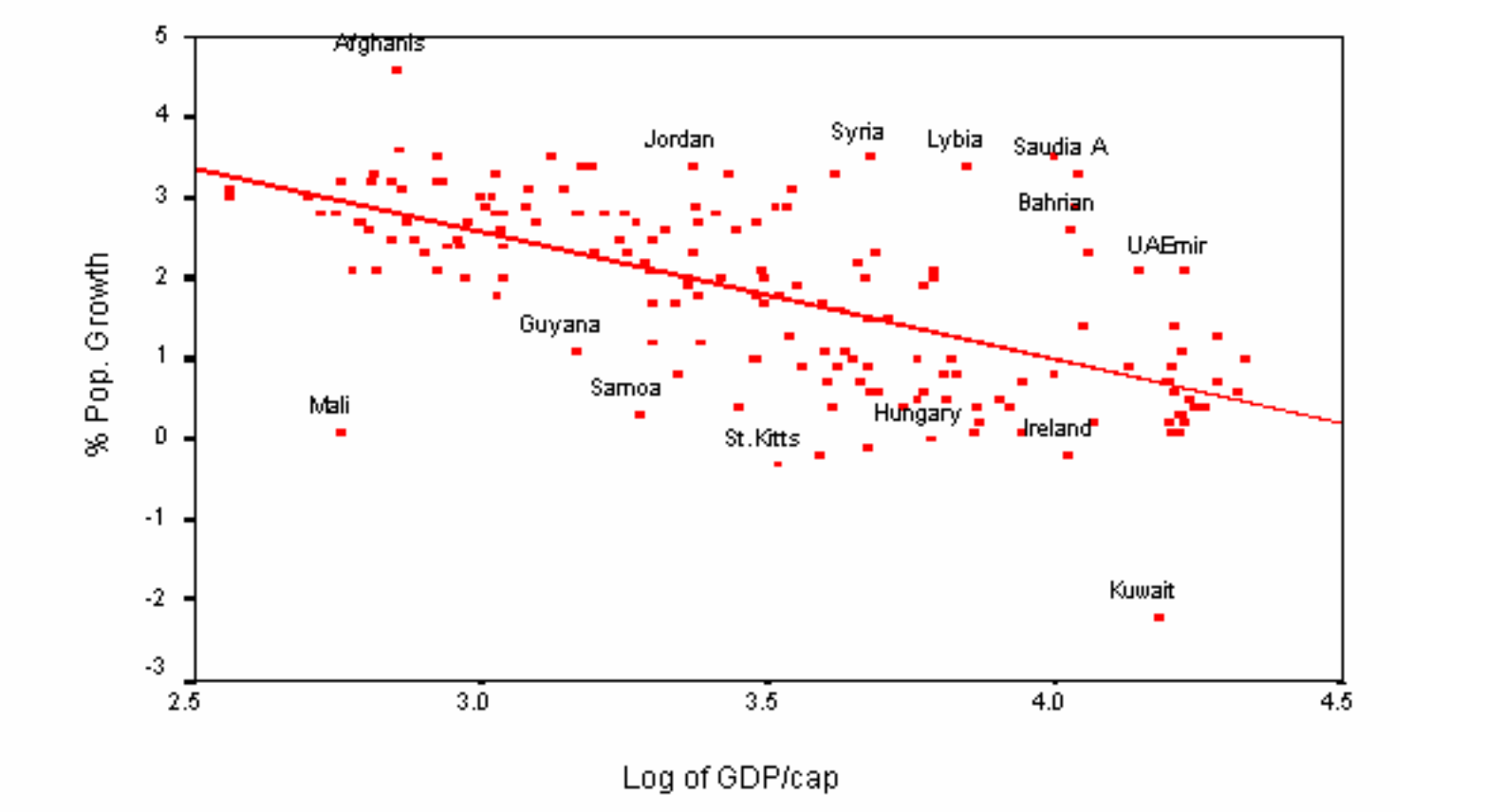
**Two approaches, two different outcomes:**




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

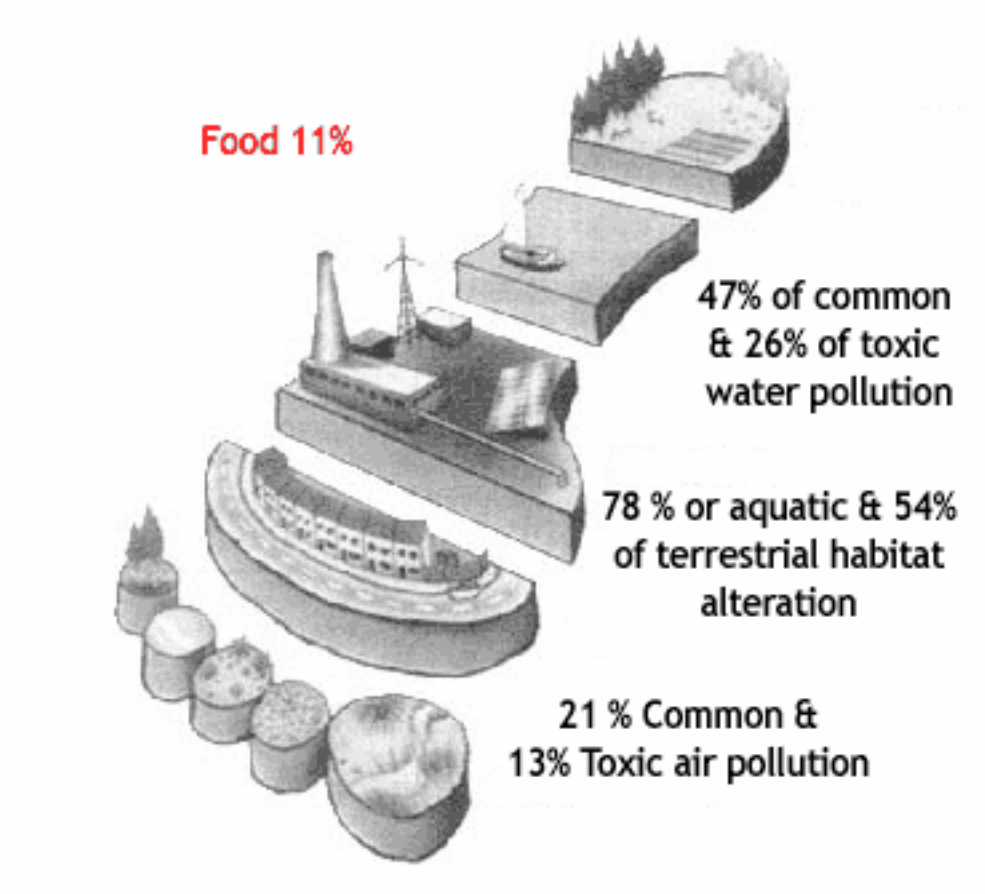
Southeast Asia and China:
Ferment feces before using
as fertilizer on crops: eliminated hookworm, only.

# Population Growth and Poverty

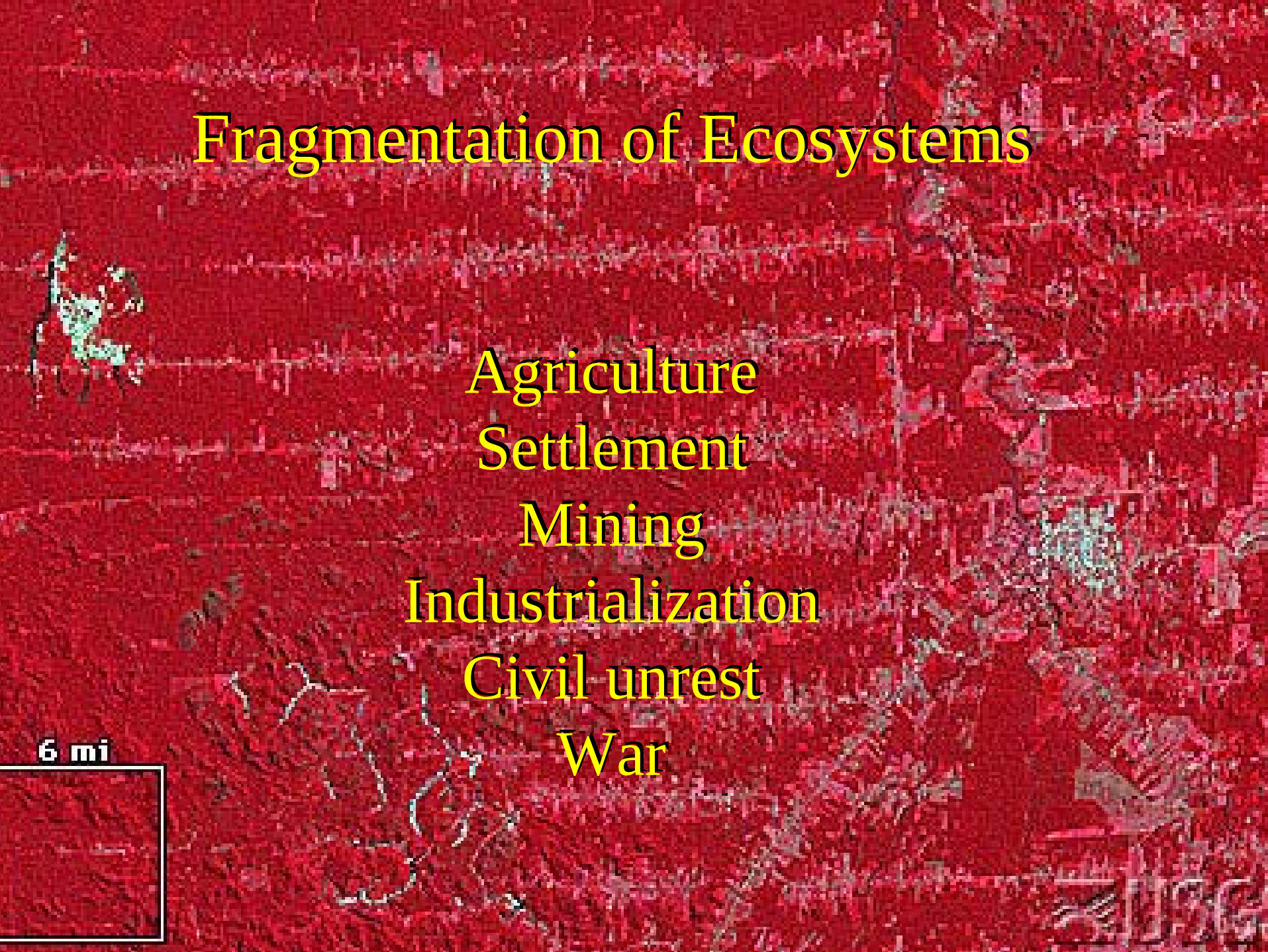



OUR ECOLOGICAL FOOTPRINT
Reducing Human Impact on the Earth
MATHIS WACKERNAGEL & WILLIAM REES
Illustrated by Phil Testemale
THE NEW CATALYST BIOREGIONAL SERIES
Mathis Wackernagel
William Rees

# The Impact of Food Production on the Ecological Landscape



# Fragmentation of Ecosystems




Agriculture
Settlement
Mining
Industrialization
Civil unrest
War

# Sources Of Pollution

## Non-point Sources:

1. Agricultural*
2. Residential

## Point Sources:

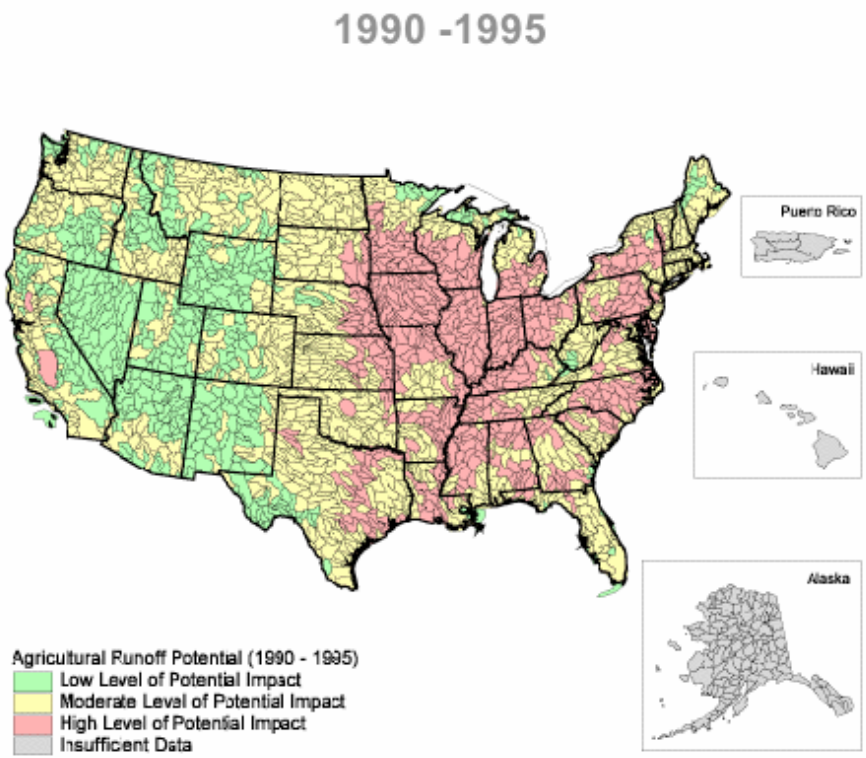
1. Industrial
2. Residential

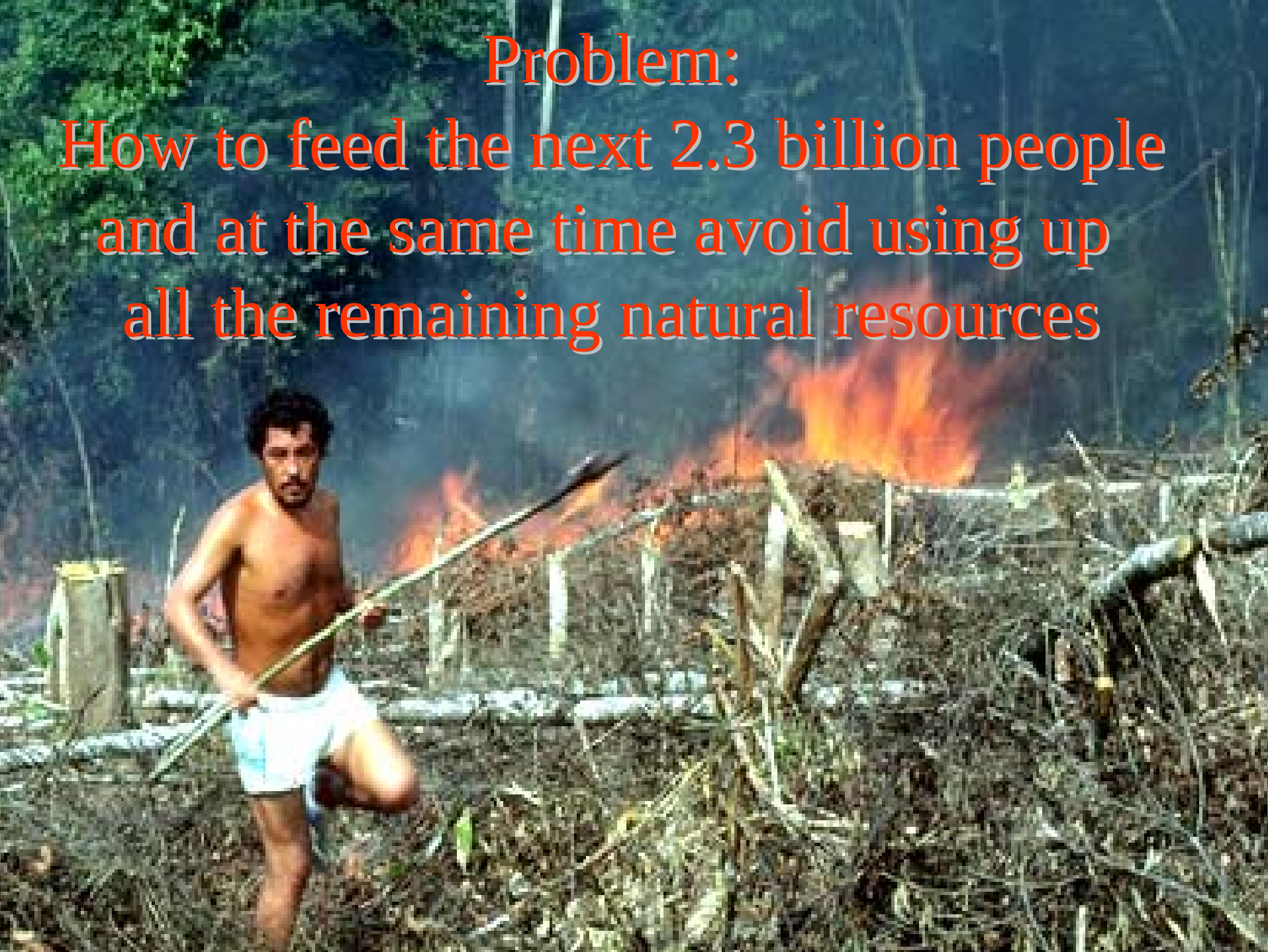
*Largest world-wide source - soil erosion, pesticides, fertilizers, herbicides, heavy metals, animal and human waste, etc.

# Estimated Overall Waste from US Agriculture (1999 figures)

1. Topsoil erosion - 1,500 MMT
2. Undigested and un-recycled feedstuffs - 25 MMT

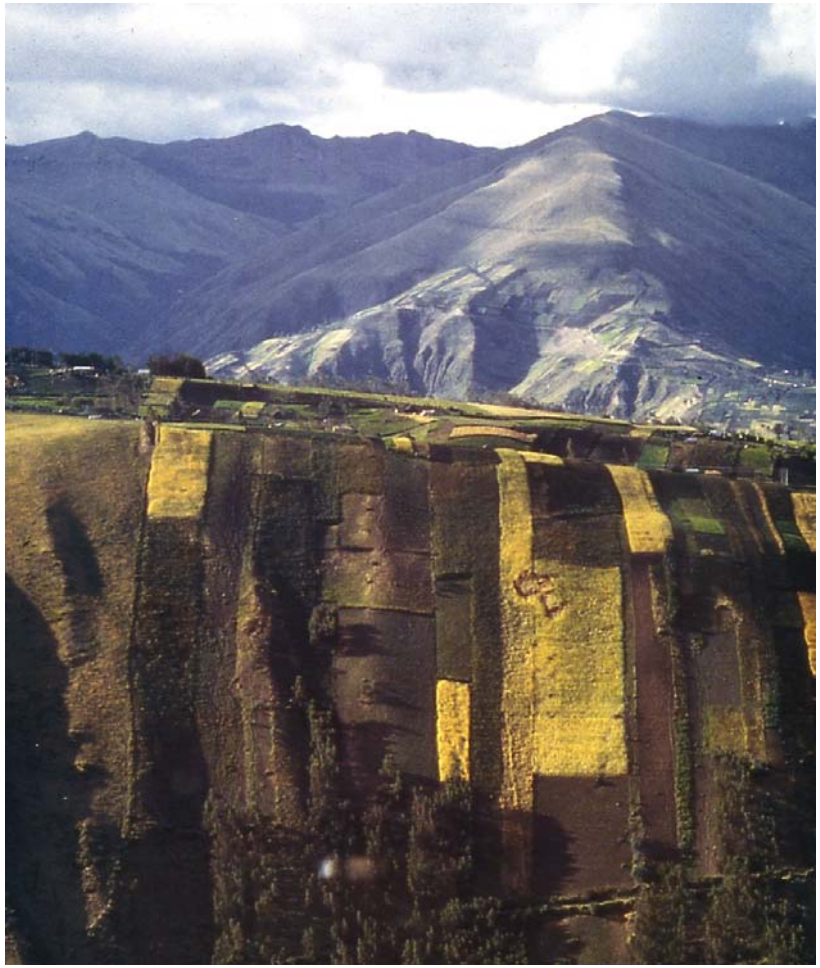
## Agricultural Runoff Potential




Problem:
How to feed the next 2.3 billion people
and at the same time avoid using up
all the remaining natural resources

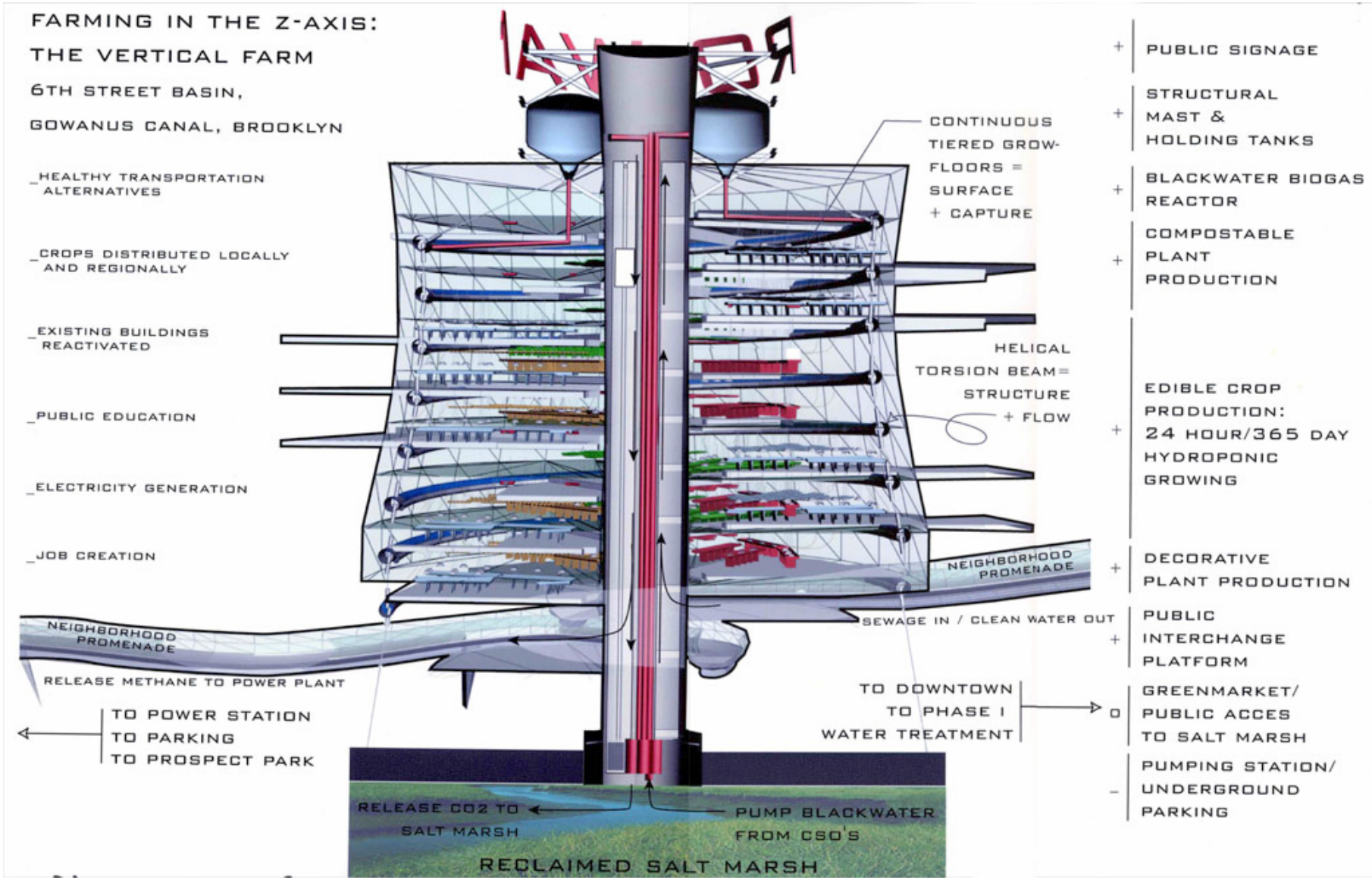
*A Possible Solution:*
*The Vertical Farm*

# *Another kind of  vertical farm**



** Again, not exactly what I had in mind.*

# *Vertical Farm* (www.verticalfarm.com)




Andrew Kranis

# The Living Tower - Pierre Sartoux

# Vertical Farms

Chris Jacobs

# URBAN ECOLOGY

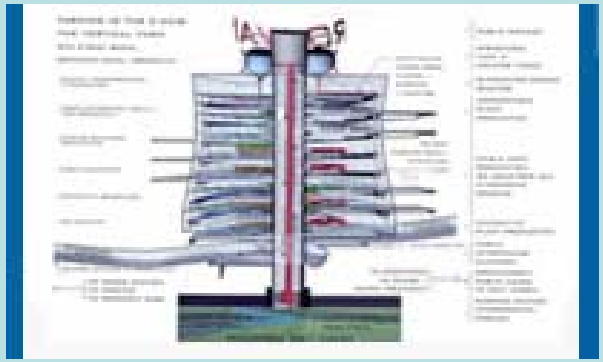
Vibrant, successful cities are not only possible but necessary for the health of society and our planet. Urban Ecology plans and designs cities that sustain the people, natural resources, and economy necessary for everyone to thrive.

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 Agricul



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*

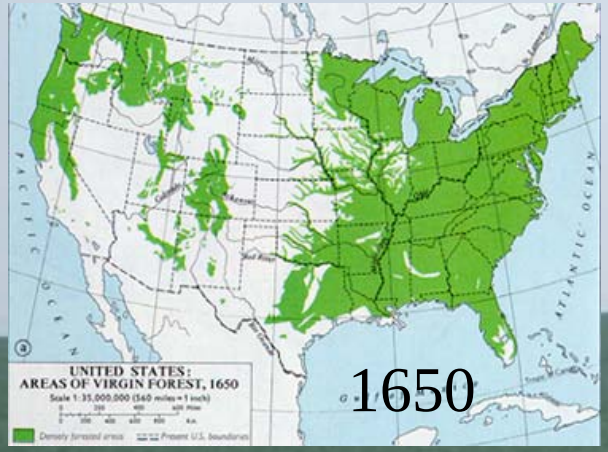
# *Returns farm land to nature, restoring ecosystem services*

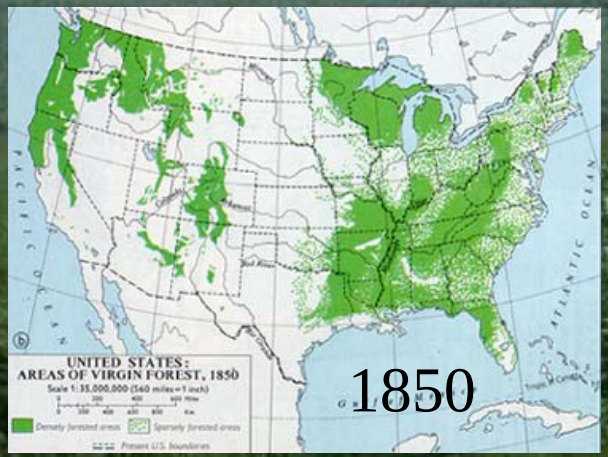


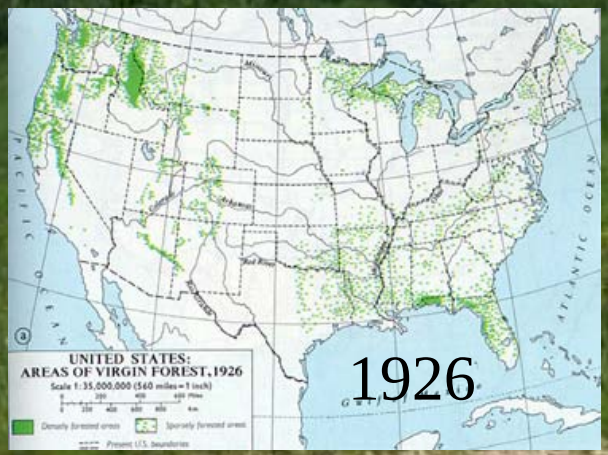
## Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems

by
**Gretchen C. Daily, Susan Alexander, Paul R. Ehrlich, Larry Goulder, 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

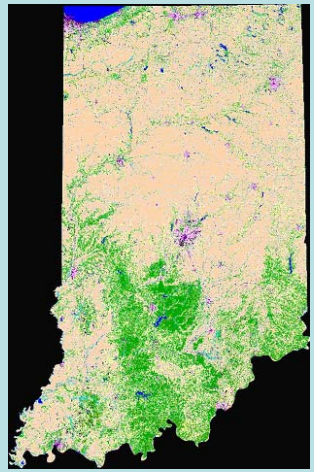


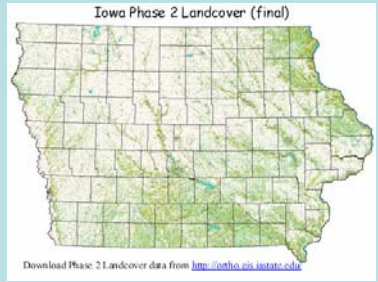

Corn, Cotton, Sorghum

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

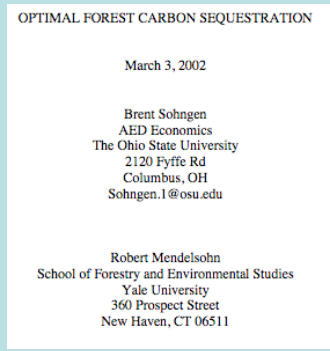



Total = 55 million acres

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

Carbon sequestration = 11 million tons of C/yr

% $CO_2$ removed from atmosphere/yr = 4%



OPTIMAL FOREST CARBON SEQUESTRATION

March 3, 2002

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Robert Mendelsohn
School of Forestry and Environmental Studies
Yale University
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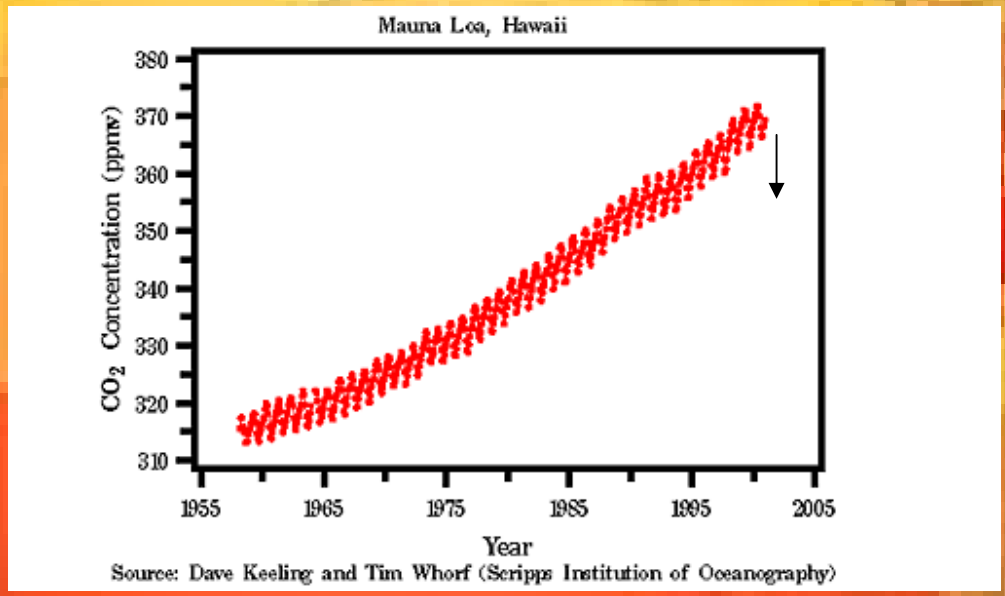
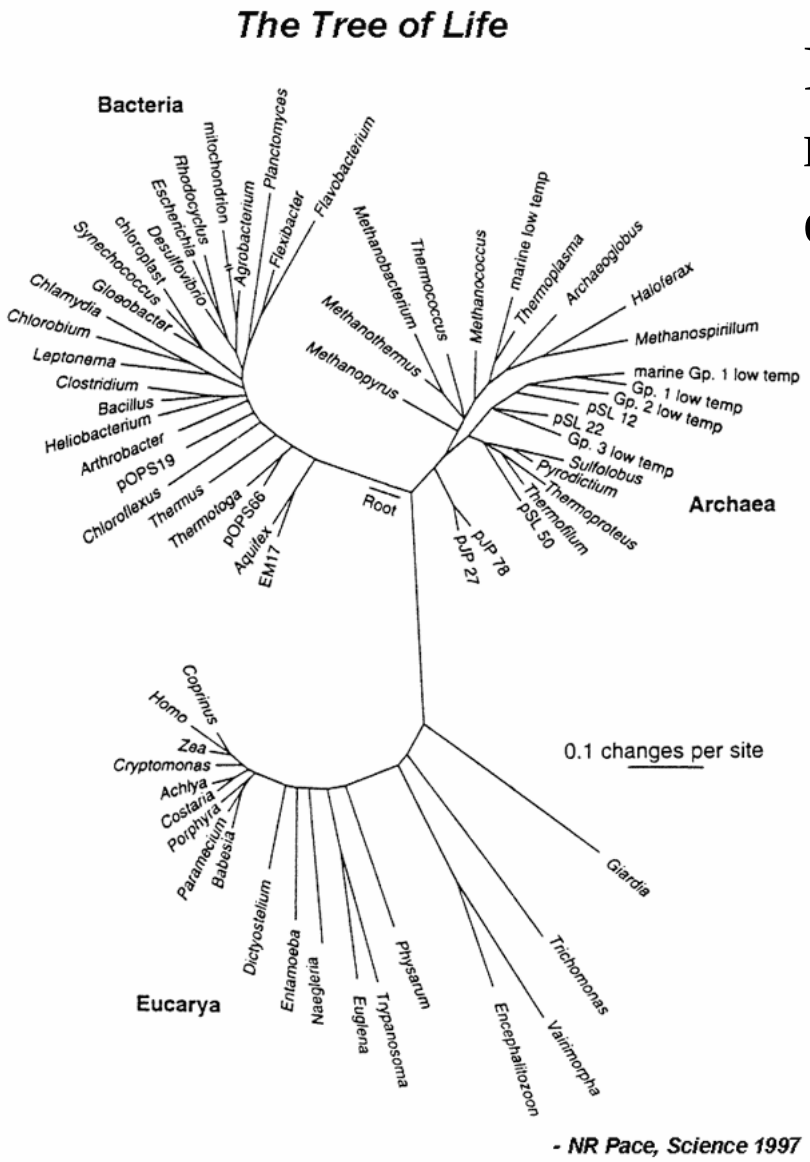
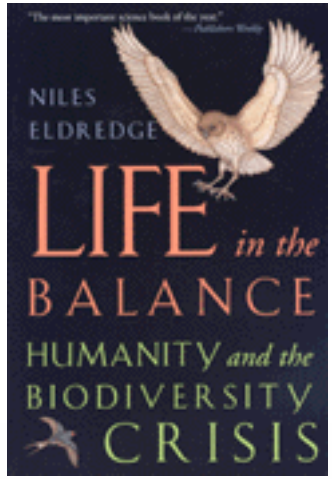
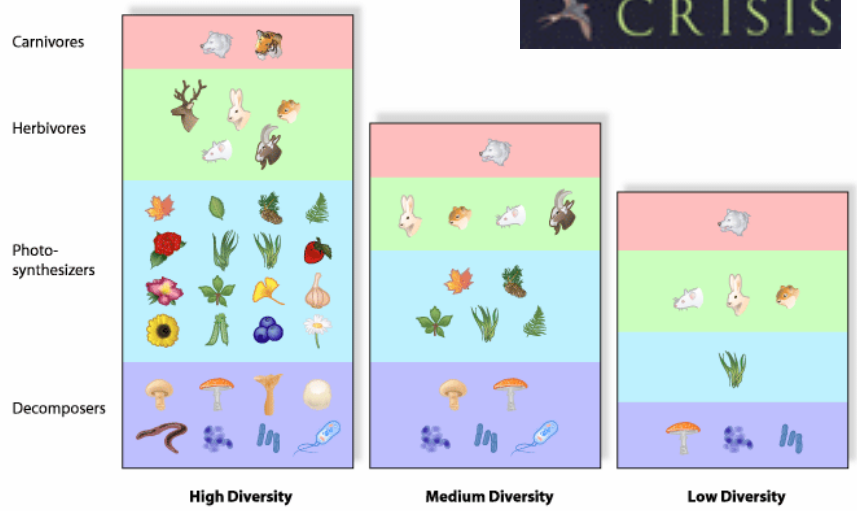

Mauna Loa, Hawaii
380
370
360
350
340
330
320
310
$CO_2$ Concentration (ppmv)
1955
1965
1975
1985
1995
2005
Year
Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)




Restoring ecosystem functions means increasing the biodiversity of a given area.



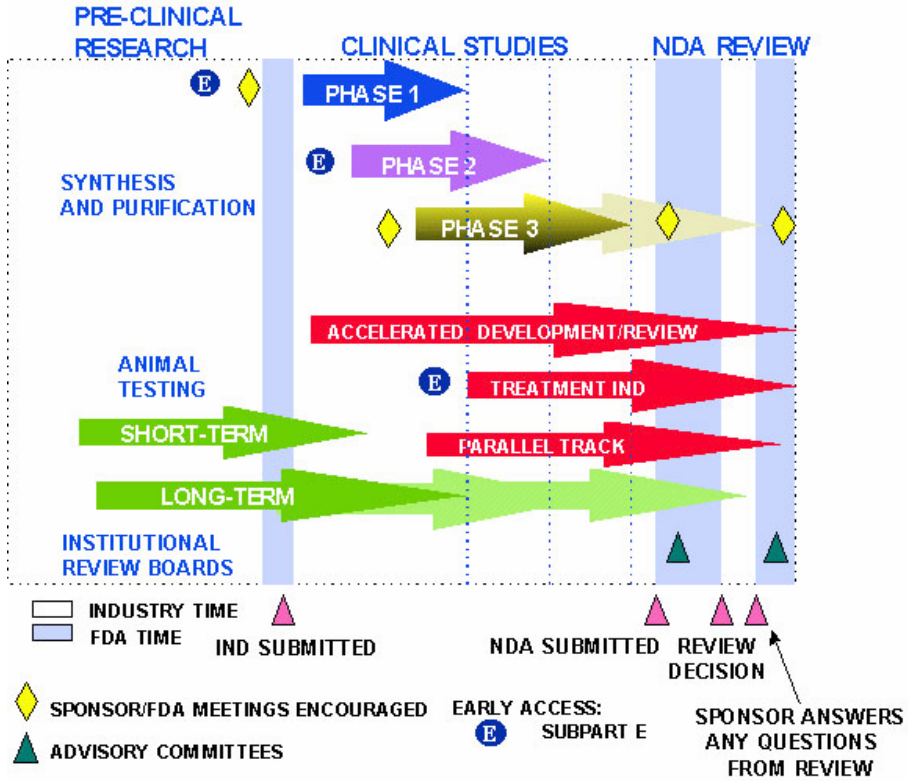



# One small advantage of improving the biod

## 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)

## Fast Tracking Drug Development




# 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.

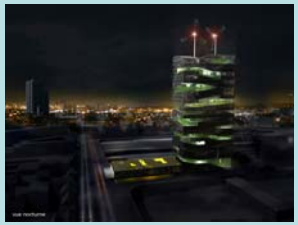
2. That building will require 26 million kW hrs of electricity.

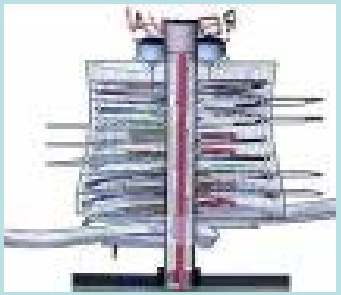
3. The same building will generate 56 million kW hrs via methane digestion and capture of solar radiation.

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

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

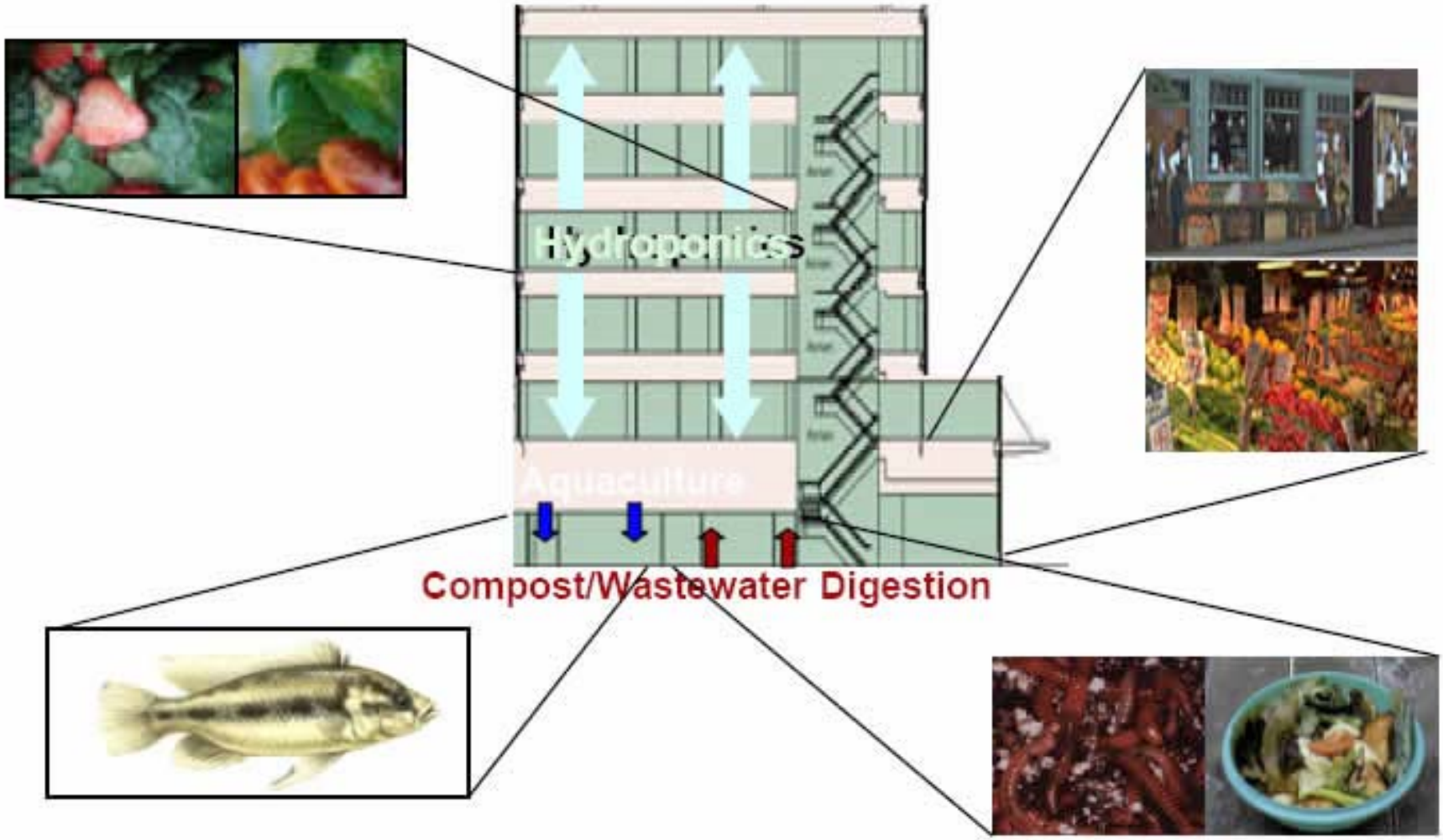
6. Forget beef! Just get over it. Remember BSE and move on!



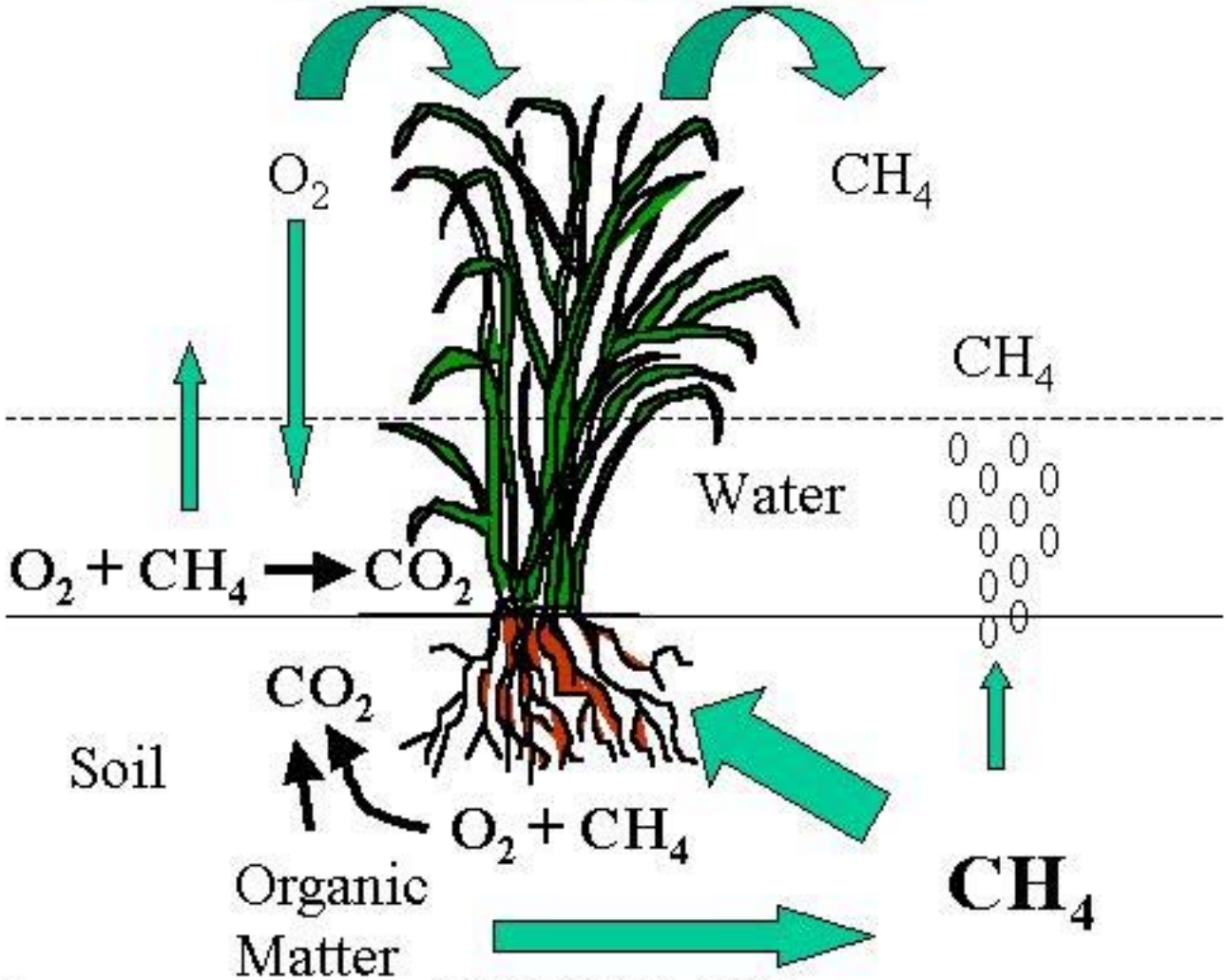


# *How It Could Work*

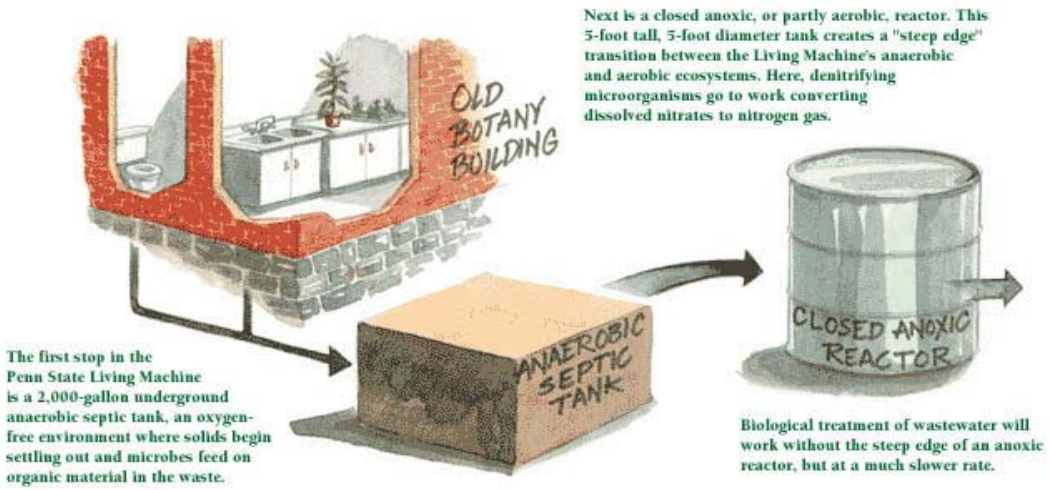
Sustainability through re-cycling.
If the rest of nature can do it, so can we!



# Methane Production and Oxidation



# Living Machines!




The first stop in the Penn 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.

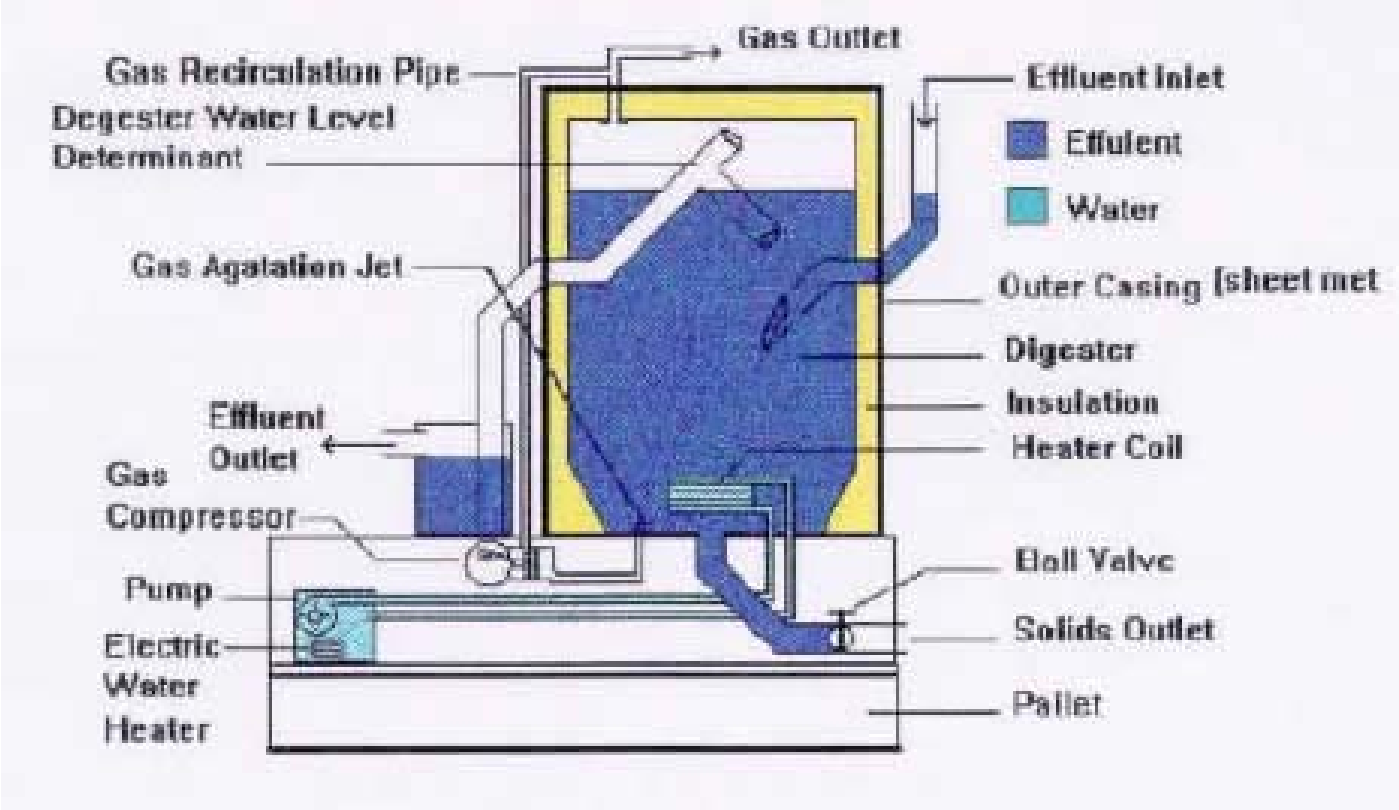
Next is a closed anoxic, or partly aerobic, reactor. This 5-foot tall, 5-foot diameter tank creates a "steep edge" transition between the Living Machine's anaerobic and aerobic ecosystems. Here, denitrifying microorganisms go to work converting dissolved nitrates to nitrogen gas.

Biological treatment of wastewater will work without the steep edge of an anoxic reactor, but at a much slower rate.

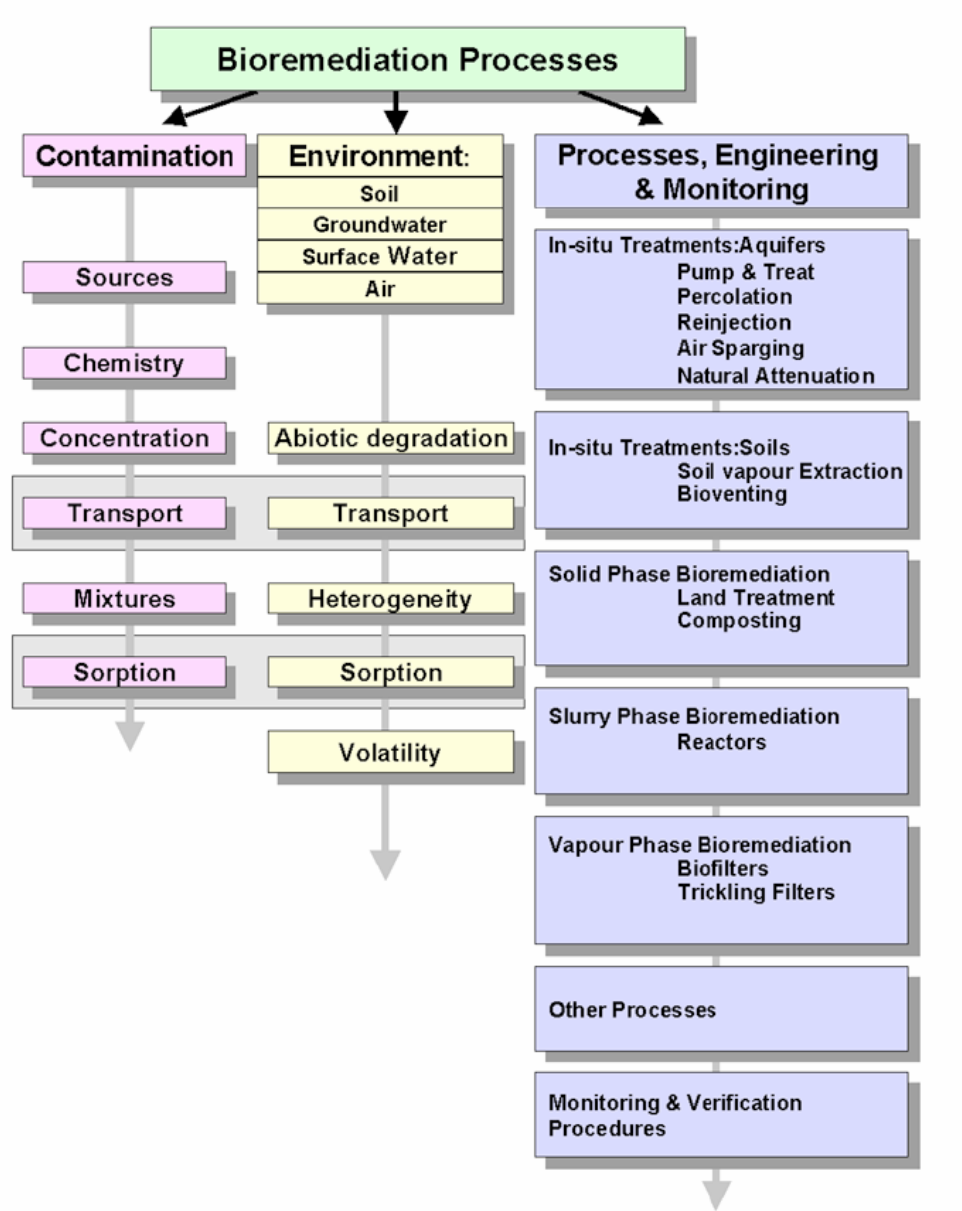
# Biodigesters

# *Methane Digester*

*No new technology needed*

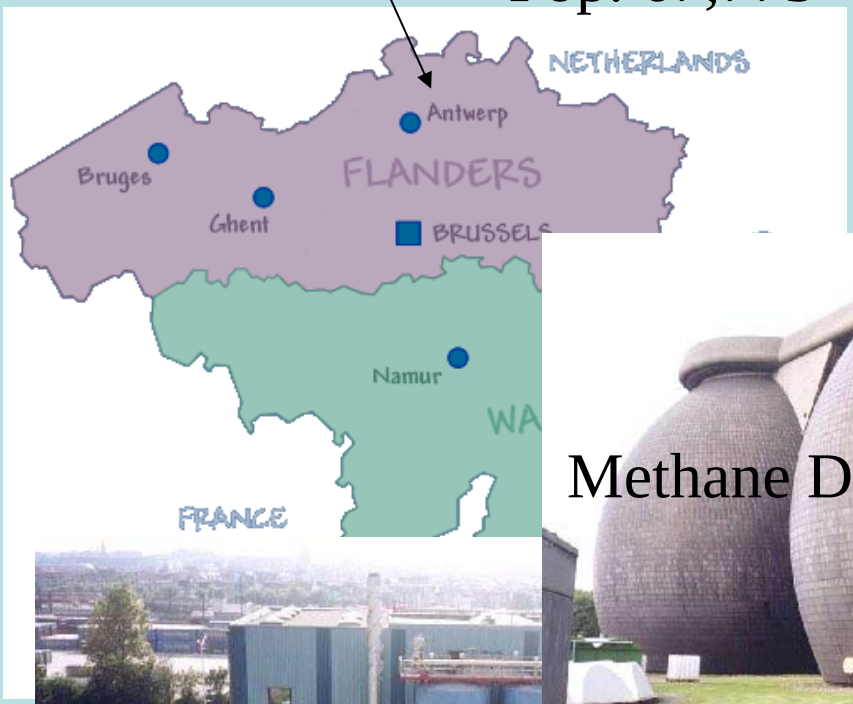


# Online Methane Digester

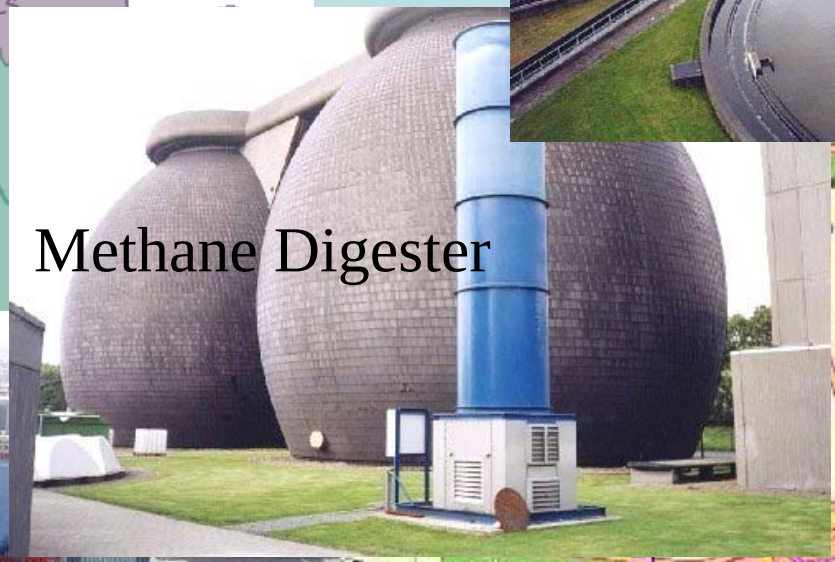

Bioremediation Processes
Contamination
Environment:
Soil
Groundwater
Surface Water
Air
Processes, Engineering & Monitoring
Sources
Chemistry
Concentration
Transport
Mixtures
Sorption
Abiotic degradation
Transport
Heterogeneity
Sorption
Volatility
In-situ Treatments:Aquifers
Pump & Treat
Percolation
Reinjection
Air Sparging
Natural Attenuation
In-situ Treatments:Soils
Soil vapour Extraction
Bioventing
Solid Phase Bioremediation
Land Treatment
Composting
Slurry Phase Bioremediation
Reactors
Vapour Phase Bioremediation
Biofilters
Trickling Filters
Other Processes
Monitoring & Verification Procedures

# Deurne, Belgium

Pop. 67,773




Raw Sewage



Methane Digester

Sludge Dryer

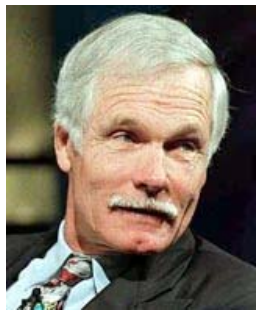
# How to Proceed:

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

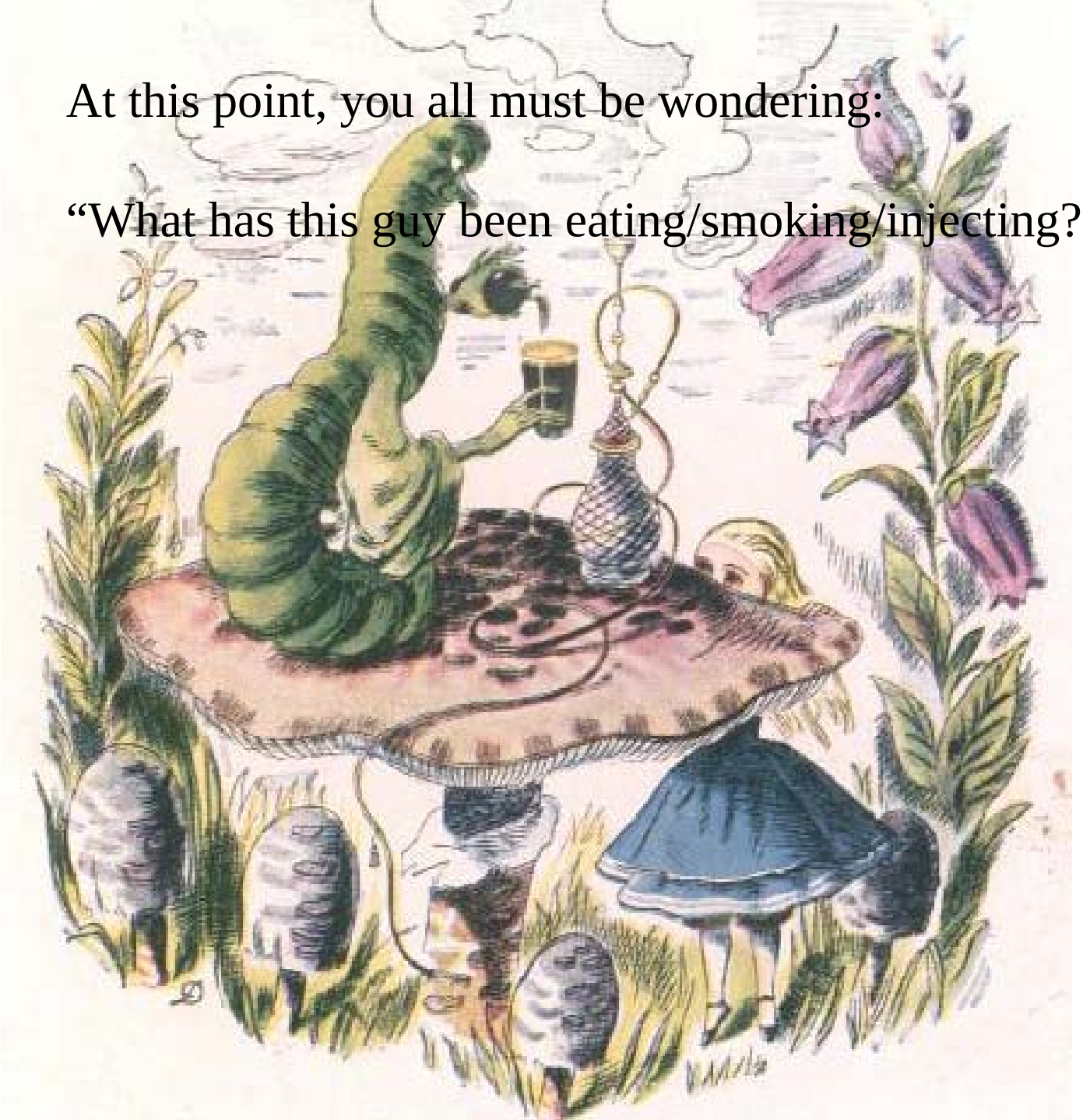
Ross Perot

| Top 10 Drug Companies | Logo | 2004 Revenues |
|---|---|---|
| 1. Johnson & Johnson |  | 22.1 billion |
| 2. Merck & Co |  | 21 billion |
| 3. Novartis |  | 18 billion |
| 4. Bristol-Myers Squibb Company |  | 15 billion |
| 5. GlaxoWellcome |  | 31 billion |
| 6. SmithKline Beecham |  | ? |
| 7. Roche |  | 13 billion |
| 8. American Home Products | | ? |
| 9. Pfizer |  | 46 billion |
| 10. Abbott Laboratories |  | 11 billion |

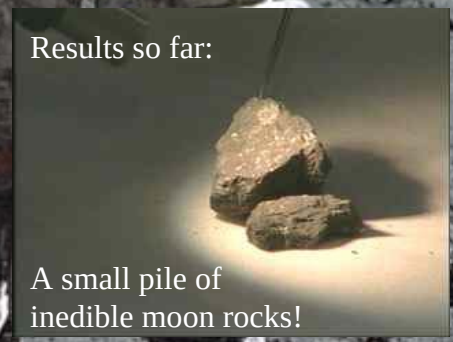

Total - 177.1 billion

At this point, you all must be wondering:

“What has this guy been eating/smoking/injecting?”



: New Moon Shots Budget = $24 billion

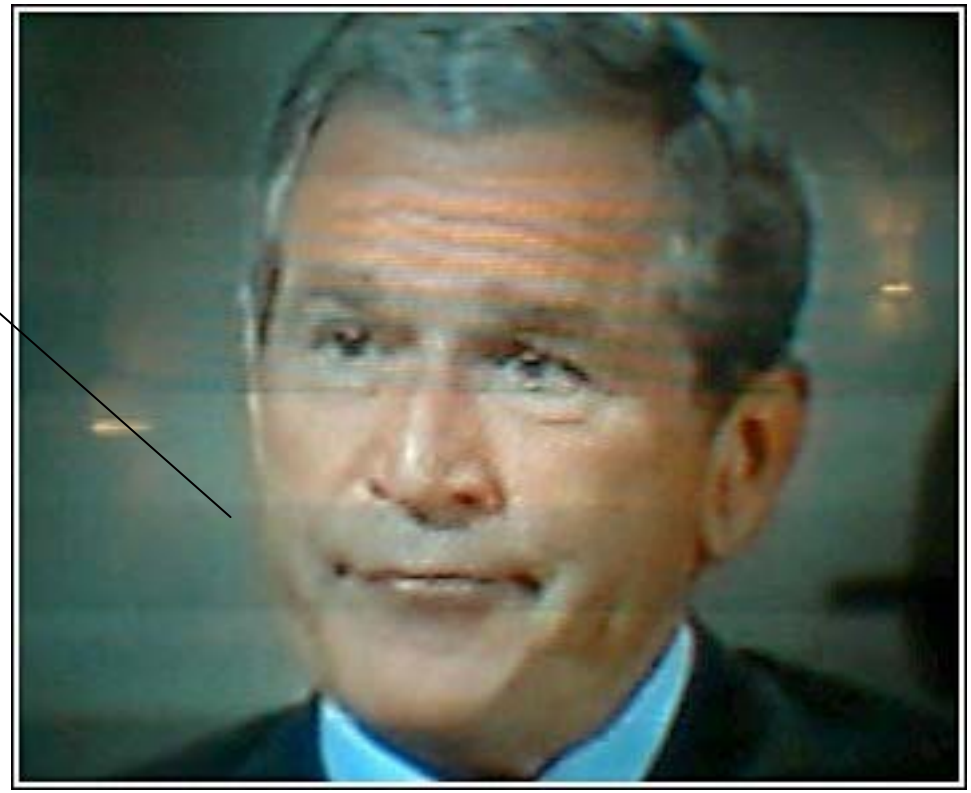


Total cost to fund vertical farm project = $18 billion
Anticipated result: Unlimited food supply for 8.3 billion people

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,…….

Yup!

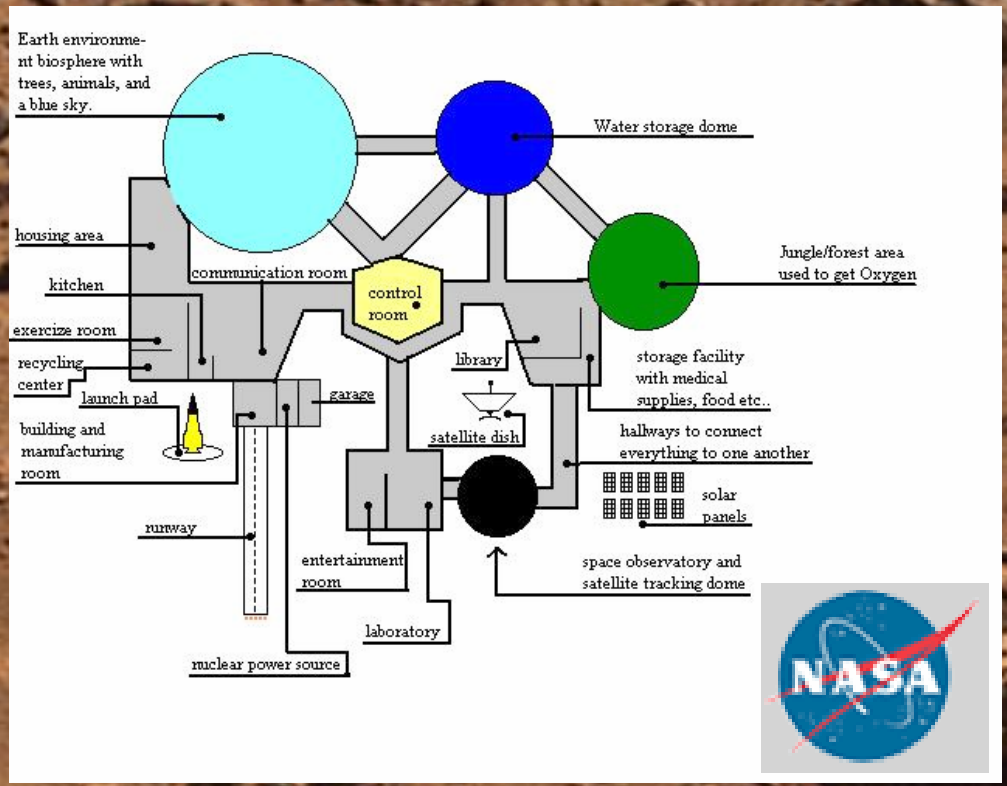



…what did *these* people eat?

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

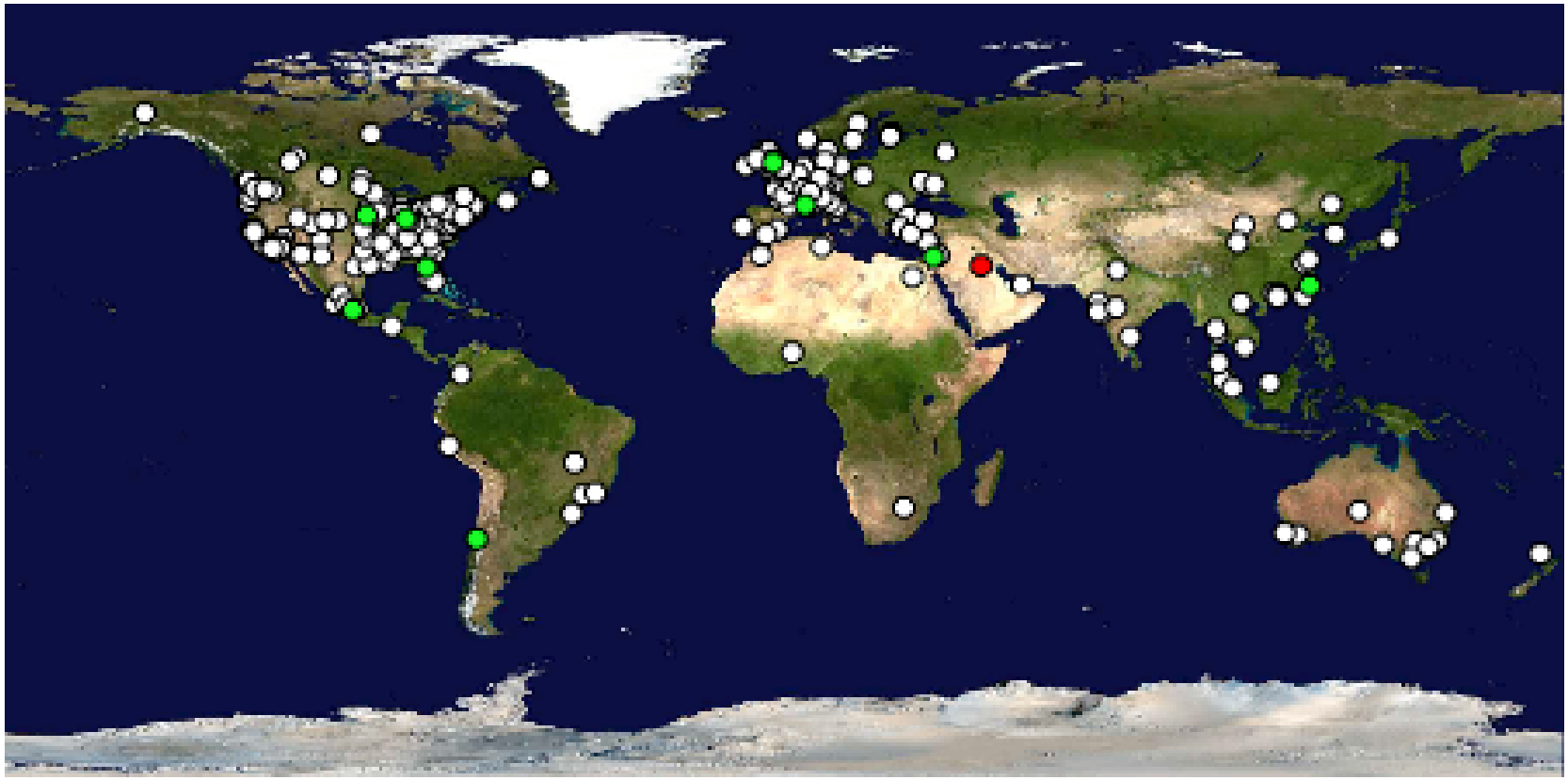
# … or attempt to live on Mars.



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

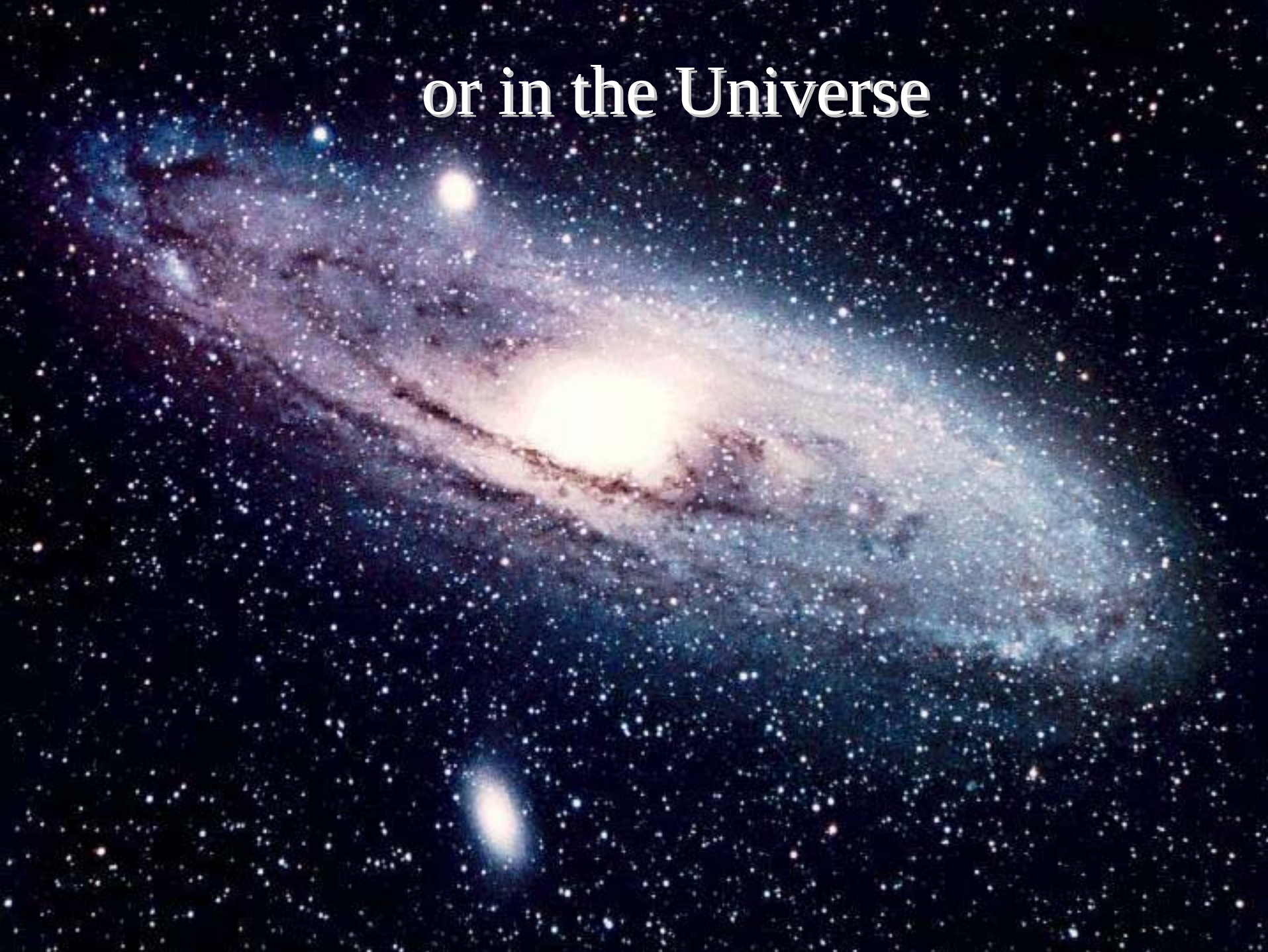

The Dawn Of
A New Beginning
(perhaps)

# *So, What's For Dinner?*

# Anything You Want

# Any Time You Want It

# Any place on earth


or in the Universe