Understanding Global Climate Change & Limits to Growth: Issues & Stakeholder Response

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Survey

• How serious is Global Climate Change & Are we Close to Solutions?
• A) Not a serious threat
• B) Serious threat, but not an uncontrollable problem
• C) Serious threat, requires major work
• D) Serious threat, requires a major paradigm shift, major work, and we’ll still lose ground
Causes

Sunlight passes through the atmosphere and warms the Earth’s surface. This heat is radiated back toward space.

Most of the outgoing heat is absorbed by greenhouse gas molecules and re-emitted in all directions, warming the surface of the Earth and the lower atmosphere.
Issues & Questions

• Is there a problem? Does Global Warming really exist?
• How bad is the problem?
• Can the problem be solved or reduced?
• Who are the decision makers or actors?
• How can we solve it?
• How really?
The Role of NASA

• In 2004, NASA's spending on climate science exceeded all other Federal agencies, combined. NASA spent $1.3 billion on climate science that year, out of a $1.9 billion total.

• In 1976, Congress revised the Space Act to give NASA authority to carry out stratospheric ozone research, formalizing the agency’s movement into the Earth sciences. (see http://climate.nasa.gov/NasaRole/)
Data, NASA, 2012

For 650,000 years, atmospheric CO$_2$ has never been above this line ... until now.
Loss of Ice

• 400 billion tons of ice loss in glaciers per year since 1994
Andes: Qore Kalis Glacier

Photographed by Lonnie G. Thompson in July 1978 (left) and again by Lonnie G. Thompson in July 2004 (right). From the Glacier Photograph Collection. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.
Arctic Sea Ice Loss
Economic Answer: Free Market & Technology

- Put a tax on carbon; higher price will encourage conservation (new technology)
- Substitution effect: Development of Alternative fuels (not fossil fuels)
- **Status Quo Effect**: large firms (fossil fuel) make profit. *Push disinformation*: Taxes & Carbon offset MKT is bad, push *belief that slows growth, jobs.* not politically correct ...
- Not true, propaganda = Delay; citizen votes
Scientific Method

• 1 study does not prove a relationship
• *Do not cherry pick studies!* - Science progresses through a long, cyclical process
• *Tobacco industry* – several studies show tobacco is unrelated to lung cancer ... wrong.
• Science is a long process, falsifiability, *delay*.
• Policymakers sometimes need to act quickly
• Precautionary Policy
Conventional belief:
- Regulation slows growth
- Budgets, spending out of control
- Extreme end believes government actions to help environment hurt the economy

Extremes:
- Business has negative impact on environment: climate change is so bad, we are doomed.

Truth: Renewable energy, green business creates jobs & flourishing, well-being: win-win. We can use business as a positive tool; if fossil fuel/large Corp. don’t sabotage positive change with propaganda.

Cherry picking
Opinions of Climate and Earth Scientists on Global Warming

Largely Caused By Humans

- Farnsworth & Lichter (2011)
  - AGU / AMS Member Scientists: 84%
  - 200 Most Published Climate Scientists: 98%

- Doran & Zimmerman (2009)
  - Most Frequently Published Climatologists: 88%
  - Scientists Publishing on Climate Change: 90%
  - Climatologists: 94%
  - Earth Science Faculty / Researchers: 82%

Little or No Human Effect

- Bray & Von Storch (2008)
  - Climate Scientists: 5%
  - AGU / AMS Member Scientists: 6%

- STATS / Harris Interactive (2007)
  - AGU / AMS Member Scientists: 3%
  - AGU / AMS Member Scientists: 1%

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We have the tools (Economic & Business actions) guided by policy to solve the Climate problem

- Our business systems have been unconstrained to produce growth (without concern for negative impacts: people & planet)
- Proper regulation, carbon taxes, can use the tool to benefit the common good, flourishing
Model of Public Policy, Citizens and Action

- Public
- Science
- Government

Actions
- Correct Problem
- Side Effects
  - Negative: Economic Issues: for some status quo Co.s, + opportunity
  - Positive: Opportunities

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Why we need Good Public Policy

production of gas

production of gas guzzlers

mkt price (gas guzzlers)

demand for gas guzzlers

production of green cars

mkt price of green cars

R, Green Demand

mkt price of gas

demand for green cars

demand for gas guzzlers

production cost / green car

production cost / gas guzzler

mkt price of green cars

mkt price (gas guzzlers)

gas tax

oil production / imports

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• Move consumers in *socially responsible* direction. Policy as a tool for common good.
Wait and See

• Can't we wait and fix the climate if things get really bad?
• When you're driving a car, you can slow down just like that. When you're driving a planet's atmosphere, you need to slow down decades ahead.
• Very different time scales, observe & react.
Facts: NCAR, National Center for Atmospheric Research

• Earth's temperature has gone up 1.4 C degrees in the last century.

• [http://ncar.ucar.edu/](http://ncar.ucar.edu/)

• As Earth heats up, the Sun sucks water from the land, creating *droughts* in some places. Warmer air absorbs the water like a sponge and then dumps it, big time, *flooding* other places.
Global Impacts, Oceans

• The more $\text{CO}_2$ the oceans absorb, the more acidic they become, and this change is killing coral reefs and other marine life.

• The increased acidity lowers the concentration of carbonate ion, a building block of the calcium carbonate that many marine organisms use to grow their skeletons and create coral reef structures.
Global Impacts, Oceans, cont.

• **Mass coral bleaching**: Mass bleaching occurs when *unusually warm* temperatures cause the coral to expel the colorful microscopic algae that provide the coral polyps with food.

• Impacts on marine food webs, **biodiversity**, ocean productivity – “world of jellyfish.”

• http://www.ucar.edu/news/releases/2006/acidification.shtml
Global Impacts, Oceans, cont.

- Warmer ocean water provides increased energy for tropical storms
- We can expect more storms, and more severe storms
- Global weather imbalance and changes affect agricultural productivity
- Tremendous economic impacts
- Investments in mitigation, adaptation
Degrees of Change

• If all industrial activity stopped now, we would still see a rise of 1 degree C
• 2 degrees C, Greenland’s glaciers disappear, low lying islands, gone
• 3 degrees C, Arctic ice gone in summer, Amazon starts to dry up, extreme weather norm; 4 degrees C, Oceans rise dramatically
MIT Study: 1 - The Input Data

Emissions, inflow, (billions of tons/year)

Anthropogenic CO2 Emissions

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Step 3 – Subjects asked to sketch the likely future CO$_2$ emissions given this scenario above.
MIT Study – 3, Example Results

Emissions, inflow

Anthropogenic CO2 Emissions

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MIT Study – 3, Example Results

Emissions, inflow

Anthropogenic CO2 Emissions

Emissions
Net Removal
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What if we stop increasing emissions?
Even at the current emissions rate, CO2 is released into the atmosphere nearly twice as fast as it is removed—so the bathtub will continue to fill.

How do we cause CO2 emissions?
Four-fifths is from burning fossil fuels. Nearly all the rest is from deforestation and other changes in land use.

How does CO2 cause warming?
It absorbs some of the heat radiation coming off Earth’s sunbaked surface and reradiates it back downward.

Where does our CO2 go?
Plants and soil absorb about a third each year, and ocean surface waters about a quarter. The rest stays airborne for a long time.

OUT 5 billion metric tons a year

350 parts per million

400 parts per million

410 parts per million

IN 9.1 billion metric tons a year

No one is sure. Some scientists think we need to reduce the CO2 level back down to 350 parts per million (ppm)—equivalent to 745 billion metric tons of carbon—to avoid serious climate impacts. But if current emissions trends continue, 450 ppm will be passed well before mid-century.

How much is too much?

Hasn’t CO2 been this high before?
Not for at least 800,000 years, say the oldest air bubbles found in Antarctic ice cores—and probably not for millions of years.

Remains in atmosphere 45%

Absorbed by plants & soils 30%

Absorbed by oceans 25%

Absorbed by sediments & rocks* <1%

* Percentages do not add up to 100 because of rounding.
The larger problem: Sustainability

- Climate change is the most imminent & all encompassing threat
- Can be handled: carbon tax, regulation, etc.
- Planetary limits go beyond climate
- Business growth (GDP), population growth
US, National Decision Making

- Democracy is slow
- Requires citizens to know, care & take responsibility
- **Short-termism!!!** Short-term sacrifice?
- **Bounded rationality (time value of $, jobs, business growth) vs. global rationality**
- **Mental Model of citizens, policy makers**
Why do Businesses Need to Grow?

• **Supplier contracts**: Ordering large quantities results in discounts (*Quantity discounts*)

• **Specialization** – Leads to specialized machinery, simple tasks, ... *the assembly line*

• **Learning Curve Effects** – With high volume comes increased knowledge to reduce costs

• **Bargaining Power** – Suppliers or Buyers can negotiate better contracts, see (1) above
Why do Businesses Need to Grow?

• Investment Power – can invest in new assets easier if one has high volume
• Economies of Scale
• Innovation from technology investments – more technology can lead to more specialization for machinery, for human resources (e.g., I can hire a chemist)
Why do Countries Need to Grow?

• Economics operates in **reinforcing feedback loops**

• More jobs means more spending power for consumers who buy more products, ... more product demand means more companies can justify investments and hire more people, creating more jobs with more salaries to be spent on more products ...
Investments Raise Productivity!

- New investments in technology raise productivity levels
- Companies can produce more output with fewer workers (think about machines, IT, robots, etc)
- But, greater productivity means fewer workers
- *To keep employment levels steady, we need more growth!*
• Earth is the source of resources, energy
• Earth is the sink to which we discard energy, material by-products
• Limits to growth
Ecological Economic View

- As “material flows” increase in an economic system, the materials (and by-products) must be transformed, used, and discarded.
- **Energy** must be used to perform transformations (extraction & production) and distribution.
- Products and by-products must be thrown away, & broken down & rendered harmless.
Environmental Kuznet Curves

Environmental Impacts

Developing Economies, 1
Developing Economies, 2
Developed Economies
Mature
Environmental Kuznet Curves

- Empirical evidence for EKC effects, in water & air pollution: $\text{SO}_2$, $\text{NO}$
- **Does NOT hold** for Ecological Footprint & $\text{CO}_2$
- Why? Structural: Rich societies can focus on regulations
- Why? Air & water pollution are *localized*
- Ecological Footprint & $\text{CO}_2$ are *global*
IPAT: Env Impact = Population * Affluence * Technology

• P (1%) and A (3.5%) are growing exponentially
• What level of technology will be necessary?
• $P_{2012} \times A_{2012} \times T_{2012} = P_{2052} \times A_{2052} \times T_{2052}$
• technology needs to reduce impacts of consumption by a factor of 5 times present efficiency levels! Is it reasonable?
Technology vs. Policy Resistance

• Road building programs designed to reduce congestion and amount of traffic have had the opposite effect: increasing traffic, delays and pollution. People respond to the increased capacity of roads by adjusting their behavior; driving more, taking longer commutes, and even buying more vehicles.

• Improvements in residential energy technologies have not led to reductions in household energy usage because consumers have reacted by building bigger homes and using more energy requiring appliances.
Technology will Keep pace, right?

• that \((\Delta Q/Q < \Delta \text{eco-efficiency}/\text{eco-efficiency})\)
• Jevons Paradox & Policy Resistance
• Dahmus and Gutowski collected data and compared major product categories: materials, transportation, energy generation, and food production (all time-series greater than 40 years).
• In all cases, *consumption outpaces gains from efficiency by a wide margin*
Technology will Keep pace, right?

• York et al. (2005) studied cross-national variation in the EF: Efficiency improvements do NOT counterbalance increases in economic output

• Ability to change technology does vary across environmental impacts

• Change can reduce resource use but thru substitution lead to increased use of another

• Countries can import resources & export externalities, pollution
Problem Symptoms vs. Root Cause

• Economists: *No limits to growth*
• Malthus (19th century political economist)
• Hypothesized that population growth would outpace agricultural productivity: *he was wrong.*
• In the 70’s, oil prices rose, but led to more exploration and discovery
• Lower resource prices in 80’s, resources not scarce, but, there are *many resources but, growth eventually wins out, until resource crash*
Problem Symptoms vs. Root Cause

• *If technology cannot remove the constraint or limiting factor, then growth stops:* Limits to growth.

• *If technology can remove the limit* (e.g. fossil fuels are replaced in time) then growth continues until we hit the next limit. Limits to growth.

• *Currently, we are not reducing CO₂.* Delay.
Problem Symptoms vs. Root Cause: Energy Independence

• Solving Problem **Symptoms** (quick fix) means *the fundamental problem gets worse*

• **No limits to growth?**

• Globally, **1,200 new proposed coal-fired power plants, see WRI.com**

• Newsweek’s RJ Samuelson belief that **supply side solutions** to energy problems are possible
Table 1. If we start with 1 bacterium in a bottle at 11 am and the bacteria grow at an exponential rate such that they double every minute, and fill the bottle at 12 pm, at what point will the bottle be half-full? [1].

<table>
<thead>
<tr>
<th>Time</th>
<th>Number of bacteria</th>
<th>Bottle, % full</th>
<th>Bottle, % empty</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00 am</td>
<td>1</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>11:01 am</td>
<td>2</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>11:54 am</td>
<td>18,014,398,509,482,000</td>
<td>2%</td>
<td>98%</td>
</tr>
<tr>
<td>11:55 am</td>
<td>36,028,797,018,964,000</td>
<td>3%</td>
<td>97%</td>
</tr>
<tr>
<td>11:56 am</td>
<td>72,057,594,037,927,900</td>
<td>6%</td>
<td>94%</td>
</tr>
<tr>
<td>11:57 am</td>
<td>144,115,188,075,856,000</td>
<td>13%</td>
<td>87%</td>
</tr>
<tr>
<td>11:58 am</td>
<td>288,230,376,151,712,000</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>11:59 am</td>
<td>576,460,752,303,423,000</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>1,152,921,504,606,850,000</td>
<td>100% full</td>
<td>0%</td>
</tr>
</tbody>
</table>

Note 1: Empirical forecasting and problem definition: The bottle fills for 1 hour, from 11am until full at 12pm. At 11:54am, the bottle is still 98% empty!

Note 2: Supply-side solutions: If at the last minute, 11:59, 3 new bottles are discovered, for a total of 4 bottles or 4 times the original supply, then how long does the new supply last? Answer: 2 bottles are filled at 12:01pm and by 12:02pm, all 4 bottles are filled.
Boom and bust
In most runs of the World3 computer model, rapid growth is followed by sharp decline. So far the standard run (main graphic) corresponds well with measurements of real-world equivalents (dotted lines).

STABILISED SCENARIO

In some cases limiting growth resulted in the system stabilising rather than crashing. But nowadays no realistic assumptions produce this outcome.
Requirements for Sustainable Development

• New technologies are required in many areas - energy, land protection, pollution clean up, and others - but they are (potentially available)

• New technologies are not enough - we need also drastically changed values related to population, material consumption, equity, conflict, and environmental protection.

• Economics and markets should serve as servants, not masters. They can help us to achieve goals, but they should not be used to determine goals. We must assume responsibility for deliberately designing our own future.

Dennis Meadows, 2004
Our Conclusion in 1972, Meadows (2004)

• “If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to (physical) growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.”
2004 Projection for 1900 - 2100

Resources

Population

Persistent Pollution

Food

Pollution

Resources

Population

Food

State of the World

Dennis Meadows, 2004
Our Conclusion in 2004

• Since 1972 there have not been any significant changes in the policies that drive growth in population and industrial production. Now the use of resources and generation of pollution are above sustainable levels.

• In 1972 the challenge was to slow down; now the challenge is to get back down.

• Decline is still the most probable future, and now it is much more likely - but not inevitable. But thirty years have been lost, and the period of declining growth - chosen by us or enforced by the planet - is thus much closer.

Dennis Meadows, 2004
Some Indicators of Overshoot

• Deterioration in renewable resources - surface and ground water, forests, fisheries, agricultural land.
• Rising levels of pollution.
• Growing demands for capital, resources, and labor by military and industry to secure, process, and defend resources.
• Investment in human resources (education, shelter, health care) postponed in order to provide immediate consumption and security demands.
• Rising debt; eroding goals for health and environment.
• Growing instability in natural ecosystems.
• Growing gap between rich and poor - between the powerful and the weak.  

Meadows, et. al. pp 176-177.

Dennis Meadows, 2004
Scientists & Overshoot

• Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life.

• in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about.

*World Scientists’ Warning to Humanity* signed by more than 1,600 scientists, including 102 Nobel laureates, from 70 countries, 1992.
Our Thoughts in 2004 about SD

• “Sustainable Development” is no longer a useful organizing concept for understanding global policy priorities - now we need survivable development.

• This is going to be a century of decline; if we are lucky, foresighted, and deliberate, it can be traversed without massive conflict and further damage to the globe’s natural systems.

• The technologies are available or can be quickly developed to get us back down below the long-term carrying capacity, if there is political will.

• Key leverage points are drastic increases in energy efficiency and substitution of distributed, renewable resources for centralized fossil fuel facilities. These would lower greenhouse emissions, reduce the gap between rich and poor, force development of new governance philosophies, increase the resilience of the economy, and shift the foundations of military power.
National Decision Making

• US Democracy is guided by:
• Corporations (exert a strong influence, $)
• Corp.s (fossil fuel) promote fear, misinformation
• Citizens that demand jobs, open to fear tactics
• Conventional wisdom developed from years of economic & business education (growth economics)
• Short-termism (corporations value profits now > profits later)
Global DM: Tragedy of the Commons

Edward J. Garrity, Sustainability and System Dynamics

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Global DM, Ambition & Reality

• Ambition – how willing is the global community to reduce their CO$_2$?
• Cancun – LT agreement to limit to 2C above pre-industrial levels; UNEP est. CO$_2$ Em must peak < 2020; & in 2050 must be 53% lower than 2005
• Durban outcome under the Kyoto Protocol, goal = developed countries > 25-40% below 1990 levels by 2020; reality is far below goal
Survey

• How serious is Global Climate Change & Are we Close to Solutions?
  • A) Not a serious threat
  • B) Serious threat, but not an uncontrollable problem
  • C) Serious threat, requires major work but can be fixed with carbon tax, regulation & political will. We can do it.
  • D) Serious threat, requires a major paradigm shift, major work, and (we’ll still lose ground, sure, because of delay inherent in systems, but the sooner we act the better the outcomes)